RASHTRIYA BARH AYOG

(NATIONAL COMMISSION ON FLOODS)

REPORT

VOLUME - I

सत्यमेव जयते

GOVERNMENT OF INDIA
MINISTRY OF ENERGY AND IRRIGATION
(DEPARTMENT OF IRRIGATION)
NEW DELHI

MARCH 1980

Price Rs. 70/- 25 $ 20 £ 8-16

PUBLISHED BY THE MINISTRY OF ENERGY AND IRRIGATION, DEPARTMENT OF
IRRIGATION, GOVERNMENT OF INDIA, NEW DELHI, AND PRINTED BY THE
GENERAL MANAGER, GOVT. OF INDIA PRESS, MINTO ROAD, NEW DELHI.

JAISUKHLAL HATHI
Governor, Punjab
and Chairman

Government of India
National Flood Commission,
(7th Floor), Lok Nayak Bhavan,
Khan Market

No. 8/8/77-RBA

New Delhi-110003, March 21, 1980

Dear Shri Choudhury,

I have great pleasure in presenting to you the Report of the Rashtriya Barh Ayog constituted by the Government of India Resolution No. FC-52(1)/76, dated 2nd July, 1976.

The problem of floods has been receiving increasing attention, especially since 1954 when the National Flood Policy was announced. However, the increase in flood incidence during recent years has been causing concern. It was in this context that the Ayog—the first of its kind—was set up to examine and advise on various aspects relating to floods. We have attempted to do so in this Report and made relevant recommendations.

We hope that these recommendations will receive due consideration from the Governments in the Centre and the States and pave the way for scientific management of floods and mitigation of misery caused by them.

Finally, I would like to thank the Government of India for the confidence reposed in entrusting this work to us.

With regards,

सत्यमेव जयते

Yours sincerely,

J. L. Hathi

(Jaisukhlal Hathi).

Shri A. B. A. Ghani Khan Choudhury,
Minister of Energy and Irrigation,
New Delhi.

REPORT

Volume I

Chapter

I. Introduction
II. Rivers of India
III. Floods—Incidence & Extent
IV. Analysis of Available Data on Flood Damages
V. Methods of Flood Management
VI. Past Approach & Achievements
VII. Zamindari Embankments
VIII. Effect of Development Works & Encroachments
IX. Methodology of Flood Damage Assessment
X. Areas Needing Urgent Attention
XI. Land Use & Regulation
XII. Costs & Benefits
XIII. Criteria
XIV. Future Approach
XV. Planning & Implementation
XVI. Financing
XVII. Maintenance
XVIII. Organisation
XIX. Legislation on Flood Control
XX. Collection & Publication of Data
XXI. Research Education & Training
XXII. Cyclones & Sea Erosion
XXIII. Summary of Recommendations

Volume II

Appendices

I. Questionnaire to State/Union Territories
II. Questionnaire to Arunachal Pradesh, Mizoram Nagaland & Sikkim
III. Questionnaires to various Departments/Organisations
IV. Press Notification
V. Questionnaire to Members of Parliament
VI. National Policy Statement, 3rd September, 1954 on "The Floods in the Country"
VII. Case Study on Damodar Valley Corporation
VIII. Itinerary of Ayog's visits to States, etc.
IX. Index of material available with the Ayog.

REPORT

VOLUME I

CONTENTS

CHAPTER I—INTRODUCTION

SECTION PAGE

1. Floods and droughts, a regular feature . . . 1
2. Impact of floods on life and property . . . 1
3. 1954—A landmark in flood policy . . . 1
4. Central and State Flood Control Boards . . . 1
5. Past Committees . . . 2
6. Implementation of Flood Control Programme since 1954 . . . 2
7. Recent damage trends . . . 2
8. Rashtriya Barh Ayog . . . 2
9. Questionnaire and response . . . 4
10. Visits . . . 4
11. Studies of the replies and clarifications thereof . . . 5
12. Discussion with experts . . . 5
13. National Plan . . . 5
14. Meetings of the Ayog . . . 5
15. Scheme of the Report . . . 5
16. Acknowledgements . . . 5

ANNEXURE

1.1 Welcome speech by Shri J. L. Hathi, Chairman, Rashtriya Barh Ayog, 4th December, 1976. . . . 6
1.2 Inaugural speech by Shri Jagjivan Ram, Union Minister of Agriculture & Irrigation 4th December, 1976 . 8
1·3 List of officers of Rashtriya Barh Ayog . . . 11
1·4 Dates of issue and receipt of replies in respect of questionnaire to the States as on 31-3-1980 . . . 12
1·5 Statement showing the dates of issue and receipt of replies in respect of Questionnaire to Central Organisations/ Departments . . . 12

CHAPTER II—RIVERS OF INDIA

SECTION

1. Introduction . . . 13
2. Legend of the Indian rivers . . . 13
3. The river course . . . 13
4. Types of rivers . . . 14
5. Brahmaputra region . . . 14
6. Ganga region . . . 17
7. North-west region . . . 21
8. Central India and Deccan region . . . 22
9. Flood-prone basins . . . 30

ANNEXURE PAGE

2·1 Average annual flows of river basins and storage capacities created upto 1978 40
Map of India showing river basins

CHAPTER III—FLOODS—INCIDENCE & EXTENT

SECTION

1. Definitions 41
2. Rainfall 42
3. Rivers 43
4. Causes 43
5. Geographical incidence 44
6. Extent 46
7. Magnitude of future works 47

ANNEXURE

3·1 Areas liable to floods and expected to be protected (1978) 48

CHAPTER IV—ANALYSIS OF AVAILABLE DATA ON FLOOD DAMAGES

SECTION

1. Introduction 49
2. The available data 49
3. The overall picture 49
4. Trends in areas damaged 50
5. Trends in flood losses 51
6. State-wise analysis 53
7. Flood damages and economic welfare 55
Nine charts showing trends in area affected by floods and damages—All-India, Uttar Pradesh, Bihar, West Bengal, Orissa and Assam. . . . .

ANNEXURE

4·1 Share of major States in flood damages (in current prices) in recent years 58
4·2 Area affected by floods in India 59
4·3 Damage caused by floods in India in current and constant (1952-53) prices 60
4·4 Flood damage per hectare of area affected—All-India (1952-53) prices 61
4·5 Summary statement of major trends in area affected and damages in major States 62
4·6 Uttar Pradesh—Trends in area affected by floods and damages 64
4·7 Bihar—Trends in area affected by floods and damages 67
4·8 West Bengal—Trends in area affected by floods and damages 70
4·9 Orissa—Trends in area affected by floods and damages 73
4·10 Assam—Trends in area affected by floods and damages 76
4.11 Food damage to crops and domestic product from agriculture 79
4·12 Crop damage due to floods and State domestic product from agriculture (in 1960-61 prices) 80
4·13 A: Area and Production of major kharif crops in selected flood prone districts of Uttar Pradesh . . . 81
4·13 B: Area, Production and yield of Principal kharif crops in selected districts of Bihar 82

CHAPTER V—METHODS OF FLOOD MANAGEMENT

SECTION PAGE

1. Approaches . . . 83
2. Modifying the flood . . . 83
3. Control/protection works . . . 83
4. Measures for abatement of floods . . . 89
5. Weather modifications . . . 90
6. Modifying the susceptibility of flood damage . . . 91
7. Modifying the loss burden . . . 93
8. Bearing the loss——living with floods . . . 95
9. Range of choice . . . 95

Categorisation of methods of flood control and mitigation of flood damages Chart . . .

CHAPTER VI—PAST APPROACH AND ACHIEVEMENTS

SECTION

1. Period prior to 1954 . . . 96
2. National policy on flood problems and remedies . . . 97
3. Achievements since 1954 . . . 105
4. Assessment of performance . . . 107

ANNEXURE

6.1 Floods in India—Problems and Remedies—Statement by Shri Gulzarilal Nanda, Minister for Planning and Irrigation & Power, in Lok Sabha on September 3, 1954 . . . 115

6.2 Statement showing State-wise actual expenditure on flood control, drainage, anti sea-erosion and anti-water logging schemes during the Plans . . . 117

6.3 Physical achievements of flood control works since 1954—area benefited . . . 118

6.4 Physical achievements of flood control works since 1954—length of embankments . . . 119

6.5 Physical achievements of flood control works since 1954—length of drainage channels . . . 120

6.6 Physical achievements of flood control works since 1954—Number of town's protected . . . 121

6.7 Physical achievements of flood control works since 1954—Number of villages raised . . . 122

6.8 Performance of embankments in a few flood prone States as per data available in State replies . . . 123

CHAPTER VII—ZAMINDARI EMBANKMENTS

SECTION

1. Introduction . . . 124
2. Statewise details . . . 124
3. Performance/effect on the flood problem . . . 126
4. Past Committees . . . 126
5. Maintenance . . . 127
6. The future . . . 128

CHAPTER VIII—EFFECT OF DEVELOPMENTAL WORKS AND ENCROACHMENTS

SECTION

1. Introduction . . . 130
2. Areas affected by highways, railways, etc. . . . 130
3. Past Committees . . . 134

सत्यमेव जयते

PAGE

4. Measures for improvement—views on 138
5. Encroachments 143

ANNEXURE

8.1 List of sections of National Highways and State Highways which experience distress frequently during floods in Bihar 146
8.2 List of sections of National Highways and Railway Crossings which experience distress frequently during floods in Rajasthan 147
8.3 List of sections of National Highways and State Highways which experience distress frequently during floods in Uttar Pradesh 148
8.4 Extracts from Clauses 130 and 104 of Section I of the Code of Practice for road bridges (IRC Standard : 5-1970) . 149

CHAPTER IX—METHODOLOGY OF FLOOD DAMAGE ASSESSMENT

SECTION

1. Importance of scientific assessment of flood damage 151
2. Present status of flood damage data 151
3. Views of past committees 152
4. Methodology for data collection 153
5. Procedure for estimation of crop damages 153
6. Use of contour maps and remote sensing technique 155
7. Damages to private property and loss of lives, cattle etc. 156
8. Damages to public property 156
9. Indirect damages 157
10. Additional classification of data required 157
11. Agency for collection and coordination of flood damage data 158
12. Other suggestions for improving the quality of data 159

ANNEXURE

9.1 Proforma I for reporting flood damage at the village level 160
9.2 Proforma II for reporting flood damage at the block/tehsil level and above 160

CHAPTER X—AREAS NEEDING URGENT ATTENTION

SECTION

1. Introduction 161
2. Analysis of data and priority for attention 161
3. Criteria 162
4. Damages caused in recent years 163
5. Statewise assessment of areas needing urgent attention 165

ANNEXURE

10.1 Statewise assessment of areas needing urgent attention 166

CHAPTER XI—LAND USE AND REGULATION

SECTION

1. Background 177
2. Watershed management for flood moderation 178
3. Soil conservation in crop land and watershed management during the Plans 180
4. Forest land and the flood problem 181

सत्यमेव जयते

PAGE

5. Special problems of the catchments . . . 182
6. Land use and regulation . . . 185
7. Cropping strategy and catchment management . . . 188
8. Assam . . . 189
9. Indo-Gangetic basin . . . 190
10. Uttar Pradesh . . . 191
11. Bihar . . . 192
12. West Bengal . . . 193
13. Orissa . . . 194
14. Jute and sugarcane . . . 195
15. Deep-water paddy . . . 195
16. Tals, chaurs, jheels and beels . . . 196
17. Livestock programme . . . 197

ANNEXURE

11.1 Progress of soil conservation works in the catchment of River valley Projects. . . . 198
11.2 D.O. letter, dated December 11, 1974 from Shri Jagjivan Ram, Minister of Agriculture & Irrigation to all Chief Secretaries of State Governments . . . 199
11.3 Average crop area damaged annually by flood . . . 201
11.4 Season-wise food production figures for the five major flood prone States in the country during 1975—78 . . . 201
11.5 Some selected Statistics relating to the North-Eastern Region . . . 202
11.6 Flood resistent sugarcane and jute varieties . . . 202
11.7 Improved varieties of deep water paddy . . . 202
11.1 Distribution of Prefadce and magditude of Land slides along one of Nationa' Highways

CHAPTER XII— COSTS & BENEFITS

SECTION

सत्यमेव जयते

1 Introduction . . . 203
2 Evolution of benefit cost analysis . . . 203
3 The present methodology . . . 203
4 Social benefit cost analysis . . . 204
5 Direct and indirect benefits . . . 404
6 Cost estimation . . . 205
7 Assessment of benefits . . . 208
8 Analysis of inter-related projects . . . 211
9 Risk and uncertainties . . . 211
10 Comparing costs and benefits . . . 211
11 Safeguards to ensure reliability of esimates . . . 212

ANNEXURE

12·1 Norms for estimating certain cost item—worked out by the Central Water Commission. . . . 213
12·2 Joint cost allocation for a multi-purpose river valley project, using, 'Separatable costs—Remaining benefits Method— an illustrative example. . . . 214
12·3 Examples illustrating use of discounting method . . . 215

PAGE

12·4 Discounting factor for 10 per cent interest rate . . . 219

CHAPTER XIII—CRITERIA

SECTION

1. Introduction . . . 220
2. Evolution and the present station . . . 220
3. Benefit cost ratio . . . 221
4. The criterion of cost effectiveness . . . 222
5. Degree of protection . . . 222
6. Inter-se priorities . . . 224

CHAPTER XIV— FUTURE APPROACH

SECTION

1. Introduction . . . 227
2. Policy objectives . . . 227
3. The problem and its causes . . . 227
4. Indentification of alternative methods . . . 228
5. Need for water conservation . . . 228
6. Afforestation and soil conservation . . . 228
7. Reservoirs . . . 228
8. Natural detention basins . . . 228
9. Underground water storage . . . 229
10. Safe disposal of surplus runoff . . . 229
11. Embankments . . . 229
12. Channel improvement . . . 230
13. Emergency flood ways and river diversions . . . 230
14. Interbasin transfers . . . 230
15. Bank protection and anti-erosion works . . . 230
16. Drainage improvement . . . 230
17. Physical measures not enough . . . 230
18. Modifying susceptability to flood damage . . . 231
19. Disaster preparedness . . . 231
20. Importance of non-physical measures . . . 231
21. Other physical adjustment measures. . . . 231
22. Modification of the loss burden . . . 231
23. Flood insurance . . . 231
24. Basinwise comprehensive approach . . . 232
25. Furure approach. . . . 232
26. Basinwise/Statewise approach. . . . 233
27. The Brahmaputra Region . . . 335
28. The Ganga Basin . . . 239
29. The North-Western Rivers Basin . . . 254

सत्यमेव जयते

PAGE

30 The Central India and Deccan Rivers Basins 260

ANNEXURE

14.1 Potential adjustments to floods, appropriate applications, special feature and implications for policy making 268

CHAPTER XV—PLANNING AND IMPLEMENTATION

SECTION

1 Planning an imperative need 269
2 Water resources and flood plans 269
3 Soil conservation and afforestation 270
4 Drainage 271
5 Environment and ecology 271
6 Investigations and collection of data 272
7 Planning 272
8 Formulation and processing of projects 273
9 Inter-departmental coordination 275
10 Inter-State rivers 275
11 Internaiotnal rivers 275
12 Implementation 275
13 Funds 276
14 People's participation 276
15.1 Proforma in which information is required to be furnished by the state Government in respect of flood control, drainage, anti-water logging and anti-sea erosion schemes costing Rs. 60 lakhs or less each sanctioned by the States. . . 277
15.2 Statement showing estimated spillover costs of continuing schemes as on 3/78 and likely outlay for the period 1978-83. . 277

CHAPTER XVI—FINANCING

SECTION

1 Introduction 278
2 Raising resources from beneficiaries 278
3 Pattern of financing flood control projects 280
4 Earmarking of funds 281
5 Emergent and normal schemes 282

ANNEXURE

16.1 Central Financing—the case for 283
16.2 Central Financing—the case against 285

CHAPTER XVII—MAINTENANCE

SECTION

1 Introduction 287
2 Repeated advice 287
3 Measures 288
4 Norms 290
5 Funds provided 292
6 Consequence of inadequate maintenance 292
7 Action suggested 293

सत्यमेव जयते

PAGE

8 Some ancillary items 294
9 Training 295

CHAPTER XVIII—ORGANISATION

SECTION

1 Introduction 296
2 Central organisations 296
3 Set-ups in the States 297
4 Inter-State rivers 298
5 Functioning of basin organisations 298
6 Past measures 299
7 River Basin Authorities 299
8 Organisations in the States 301

ANNEXURE

18.1 Communication No. FC-47 (3)/72 dated April, 19, 1972, constituting the Ganga Flood Control Commission. . 303

CHAPTER XIX—LEGISLATION ON FLOOD CONTROL

SECTION

1 Introduction 304
2 Legislative competence 304
3 Existing legislation 304
4 Laws enacted by the Central Government 305
5 Laws enacted by State Governments 307
6 Appraisal of State Acts 311
7 Acts on Flood Control in other countries 312
8 Appraisal 316
9 Need for comprehensive legislation in the States 317
10 Model Bill on Flood Control 317

ANNEXURE

19.1 State-wise position of legislation in respect of flood control 318

CHAPTER XX—COLLECTION AND PUBLICATION OF DATA

SECTION

1 Introduction 320
2 Types of data 320
3 Hydro-meteorological data 320
4 Topographic data 321
5 Additional data for specific project formulation 322
6 Modern advances in collection of basic data 323
7 Data handling, storage, processing and retrival 326
8 Publication of data 327

ANNEXURE

20.1 Statement showing the existing basin-wise discharge sites maintained by the CWC and those required as per W.M.O. norms excluding those of the Ganga, Indus, Chenab 328
20.2 Statement showing state-wise distribution of hydrological stations 329

PAGE

Chart showing National Hydrological Network Observation.

CHAPTER XXI—RESEARCH, EDUCATION & TRAINING

SECTION

1 Background . . . 330
2 Past recommendations and developments . . . 330
3 Global status of hydrology . . . 331
4 Country status in research . . . 332
5 Current research activities . . . 333
6 Research gaps and future research needs . . . 334
7 Research infrastructure and personnel policy . . . 339
8 Education and training . . . 339
9 In-service training . . . 339
10 Peoples' training . . . 340

ANNEXURE

21.1 List of Research Institutes of the Indian Council of Agricultural Research. . . . 341

CHAPTER XXII—CYCLONES AND SEA EROSION

SECTION

1 Introduction . . . 342
2 Cyclones . . . 342
3 Damage by cyclones . . . 342
4 The extent . . . 343
5 Measures for mitigating damage and distress . . . 345
6 Mitigating losses . . . 346
7 Sea Erosion . . . 350
8 The problem . . . 350
9 Kerala . . . 351
10 Tamilnadu . . . 351
11 Andhra Pradesh . . . 352
12 Orissa . . . 353
13 West Bengal . . . 354
14 Karnataka . . . 355
15 Maharashtra . . . 356
16 Gujarat . . . 356
17 Role of the Central Government . . . 356
18 Suggestions . . . 358

ANNEXURE

22.1 Summary of recommendations made by IMD in their Cyclone Project . . . 359
CHAPTER XXIII—SUMMARY OF RECOMMENDATION . . . 361

Abbreviation used in the Report

AIR	All India Radio
BC ratio	Benefit-Cost ratio
BFCC	Brahmaputra Flood Control Commission
CWC	Central Water Commission
CWPC	Central Water & Power Commission
CWPRS	Central Water & Power Research Station
DAD	Depth—area—duration
DCP	Data Collection Platform
DCS	Data Collection System
DVC	Damodar Valley Corporation
ECAFE	Economic Commission for Asia and the Far East
FRL	Full Reservoir Level
GFCC	Ganga Flood Control Commission
HFL	High Flood Level
HLCF	High Level Committee on Floods (1957)
ICAR	Indian Council of Agricultural Research
ICID	International Commission on Irrigation and Drainage
IMD	India Meteorological Department
INSAT	Indian National Satellite
IPC	Indian Penal Code
IRC	Indian Road Congress
ISI	Indian Standard Institution
I & W	Irrigation & Waterways
L/B	Left bank
MDAS	Multispectral Data Analysis
MOS & T	Ministry of Shipping & Transport
MRL	Maximum Reservoir Level
MSS	Multispectral Scanning System
NCA	National Commission on Agriculture
NCAER	National Council of Applied Economic Research
N E Council	North Eastern Council
NISSAT	National Information System on Science and Technology
NRSA	National Remote Sensing Agency
OAE	Other Agricultural Embankment
P & T	Posts and Telegraphs
R/B	Right bank
RBA	Rashtriya Barh Ayog
RDSO	Research, Design & Standards Organisation
REO	Rural Engineering Organisation
SEO	Satellite for Earth Observation
SR	Self recording
T & P	Tools and Plants
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific & Cultural Organisation
UNO	United Nations Organisation
WMO	World Meteorological Organisation
WRDC	World Resources Development Centre

I INTRODUCTION

1.1. Floods & droughts a regular feature

India is a vast country with a total geographical area of 3.29 million sq. km. It lies between the longitudes 68°0′ & 97°30′ east and between latitudes 8°0′ & 37°0′ north. Due to its vastness, the different regions of the country have varied climates and rainfall patterns. It is, therefore, not uncommon to find one part of the country under the grip of severe floods due to excessive rainfall while another part suffering under the effects of drought. Many a time, it so happens that even in the same State, some areas have excessive rains and consequent floods, while some other areas suffer due to poor rainfall and consequent drought.

1.2. Impact of floods on life and property

Although man has had to live with floods since the very inception of his existence, the impact of floods was not perhaps felt to the same extent in the past as is felt now, due to the much smaller number of people inhabiting the land and lesser pressure of industrial activities and other developmental works on the flood plains. There is no doubt that with the rapid increase in population and consequent increase in the all round activities of man, flood plains are being gradually occupied to ever-increasing extent to meet his requirements of food and ibre, consequently the flood problem has been accentuated. The wanton destruction of the forest wealth of the country for reclaiming areas for occupation and for obtaining fuel for domestic requirements as also the 'Jhooming' cultivation practised by the tribal population in the hilly areas have probably caused changes in river regime. All these have resulted in an anomalous situation where, in spite of the proection measures implemented during the last quarter of a century with an investment of about Rs. 700 crores and 10 million hectares having been afforded reasonable protection, the lood damages have not only not shown any ign of decrease but on the other hand have hown an increasing trend.

.3. 1954—A landmark in flood policy

Flood protection measures on a limited scale were undertaken in this country from early imes by individuals. Governmental interest in he problem developed chiefly during the past entury, when a number of well planned embankments were constructed on some of the rivers which were causing recurrent flood damage. These embankments were mostly for the protection of irrigated areas in the north and deltaic tracts of the east flowing rivers in the south. Still, it can be said that the measures taken till 1954 had touched only a fringe of the problem. The severe floods of 1954 attracted the attention of the public and the Parliament and brought into sharp focus the inadequacy of the measures taken against floods till that time. A programme of flood control was, therefore, launched at the national level in the same year. While it was considered essential to provide protection to all the people in flood affected areas, methods had to be chosen which, while achieving the objectives, could also be carried out expeditiously. Accordingly, it was decided to undertake a countrywide programme of flood control under three phases, namely (i) immediate (ii) short-term and (iii) long-term.

The immediate phase was to extend over a period of 2 years and was to be devoted to investigations, collection of data and preparation of estimates for short term measures. This was also to cover immediate works for the protection of selected towns and construction of embankments in the most vulnerable reaches. The second phase, which was to coincide with the commencement of the Second Plan, envisaged flood control measures such as embankments, channel improvements, raising of villages and protection of towns. The long-term phase, was to cover selected long-term measures such as construction of storage reservoirs on the tributaries of certain rivers and additional embankments wherever necessary.

1.4. Central and State Flood Control Boards

In order to implement the above mentioned programme, it was felt necessary to set up suitable machinery at the Central and State levels. A Central Flood Control Board was constituted under the Chairmanship of the then Union Minister of Irrigation and Power with representatives of the concerned flood prone States and Union Ministries such as Railways, Transport etc., as its Members. Also, State Flood Control Boards assisted by Technical Advisory Committees were set up in the flood affected States for assessing the flood problem, laying down policies, approving long range plans and specific schemes and fixing priorities.

Under the apex body of the Central Flood Control Board, four River Commissions namely the Ganga, the Brahmaputra, the North West and the Central India and Deccan River Commissions were set up during the fifties, to assist the Board in all technical matters including preparation of integrated plans for the river basins and examination of specific schemes to be carried out by the States.

1.5. Past Committees

Since 1954, the Central and State Governments have appointed a number of Committees to study and advise on policy matters for speedy implementation of flood control/protection programme and also to examine the flood problem in general as well as in specific areas for evolving suitable remedial measures. The Committees appointed can be broadly classified into the following three categories:—

I. Appointed by the Governent of India to deal with general flood problems in the country.

II. Appointed by the Government of India to deal with specific problems.

III. Appointed by the concerned State Governments to deal with particular problems in the States.

A resume of the background, terms of reference and recommendations of the important Committees set up may be seen in the Questionnaire to States placed at Appendix 1 of Volume II of the Report.

सत्यमेव जयते

1.6. Implementation of the Flood Control Programme since 1954.

The three phases of the programme outlined in 1954 could not be fully implemented due to various reasons; considerable work has, however, been done.

The main emphasis so far has been on the construction of embankments although some storage reservoirs with specific flood cushion have also been constructed on a few rivers as in the case of dams in the Damodar system and the Baigul reservoir in U.P. Besides, in many reservoirs like Hirakud on the Mahanadi, Bhakra on the Sutlej and Ukai on the Tapi, flood moderation is achieved by suitable operation of the reservoirs. Drainage improvement works on a large scale have been implemented especially in the States of Haryana, the Punjab, West Bengal and Andhra Pradesh.

From 1954 to March 1978, about 10,821 km of new embankments and 19,260 km of drainage channels have been constructed. In addition, 254 towns have been protected and about 4,700 villages raised above flood level. According to the figures supplied by the States, an area of about 10 million hectares has been afforded reasonable protection upto March 1978.

1.7. Recent damage trends

In spite of the progress made, the reported figures of damages have shown a substantial increase in recent years. The estimated total damages at current prices are as below:

Years	Estimated damage Rs. Crores
1954-1961	449.53
1961-1966	271.18
1966-1969	404.71
1969-1974	1979.4
1974-1978	3128.4

The estimated annual damage in the countr during the earlier years (until about 1966), wa about Rs. 65 crores. This went up substantiall during the 1971 floods when an estimated los of Rs. 632 crores was reported. The losses wen down to Rs. 158 crores in 1972 but again wen up to Rs. 569, 569, 471 and 889 crores in the nex 4 years. Thus a pattern of increasing floo damage was noticed after 1967. The averag annual damage during the period 1953-1976 i about Rs. 210 crores.

1.8. Rashtriya Barh Ayog

Noting this increasing trend in flood damage in recent years and the need for taking up effective measures for reducing the annual loss the Government of India, in the Ministry o Agriculture & Irrigation, constituted the Rashtriya Barh Ayog by their Resolution No. FC-52(1) 76 dated the 2nd July,1976. The Resolution inte alia reads as follows:—

"Sizeable progress has been made in the floo protection measures since 1954, when the National Flood Control Programme was launche for the first time, in the country. Since the nearly one third of the flood prone area has bee afforded reasonable protection. During thi period of two decades, considerable experienc has been gained in planning, implementation an performance of the flood protection and contr measures. Advancement in technology ha taken place not only in India but also in foreig countries. Therefore, it has become necessar to conduct a study in depth of our approach an programmes of flood control measures. Formulation of a flood control policy would requi detailed study of various problems concerne with flood control measures and also, aspects like soil conservation and afforestation. The Government of India have, therefore, decided to set up the Rashtriya Barh Ayog so as to evolve a coordinated, integrated and scientific approach to the flood control problem and draw out a national plan, fixing priorities which could be implemented in the near future. The composition of the Commission shall be as follows:—

(1) Shri Jaisukhlal Hathi—Chairman (Part-time)

(2) Two experts in flood control (to be nominated later)—Members

(3) One Economist (to be nominated later) —Member

(4) One Agronomist (to be nominated later) —Member

(5) Representative of the Central Water Commission, Ganga Flood Control Commission, and Brahmaputra Flood Control Commission—Members

(6) One Member-Secretary (to be nominated later)—Member-Secretary

The terms of reference of the Commission will be as follows:—

(1) To review the flood protection measures undertaken since 1954 and to make an evaluation of the benefits and effectiveness of the measures undertaken so far with special reference to embankments in reducing the damage.

(2) To identify the areas where a large number of Zamindari and/or unauthorised embankments, bunds and spurs etc., exist; to assess the effect of such constructions on the flood problem; and suggest remedial measures.

(3) To identify the areas where construction of roads, highways, railways etc., and other encroachments into drains have aggravated flood problems and to suggest measures for improvements including legislative action, if any.

(4) To analyse the damage caused by floods in recent years and to identify areas requiring immediate flood protection measures.

(5) To evolve a comprehensive approach to the problem of floods in the country keeping in view the need for optimum and multi-purpose utilisation of water resources as also the role of soil conservation and afforestation in flood control.

(6) To make an analysis of the cost and benefits of flood protection measures.

(7) To suggest criteria for taking up flood protection measures and means of mobilising resources therefor.

(8) To recommend proper land use in the flood plains with a view to minimise damage and to ensure overall increase in agriculture production.

(9) To examine the existing arrangements for maintenance of flood protection works and recommend measures for improving the same.

(10) To review the existing administrative and organisational set up for flood control at the Centre and in the States and suggest improvements where necessary, flood control to include flood forecasting and warning, flood fighting, formulation and implementation of flood protection measures.

(11) To examine the present procedure of assessing flood damage and suggest improvements.

(12) To examine any other matter related to floods and flood control and make suitable recommendations...."

Although the Ayog was officially constituted in July 1976, the formalities connected with the appointment of the Members and the setting up of the office could be completed only some time during November 1976 and the Ayog was formally inaugurated on 4th December 1976.

In his welcome speech (Annexure 1.1), the Chairman Shri Jaisukhlal Hathi, the then Governor of Haryana and at present Governor of Punjab traced the background to the setting up of the Rashtriya Barh Ayog, and sought the co-operation and assistance of all the States in supplying data and other information that might be required by the Ayog from time to time. He also requested each State Government to send preliminary memorandum on its flood and drainage problems, pending the circulation of a comprehensive questionnaire by the Ayog.

In his inaugural speech (Annexure 1.2), the then Union Minister for Agriculture and Irrigation Shri Jagjivan Ram touched upon the increasing trend of flood damages in the country and felt it might be due to the fact that there is better reporting and estimation of losses. He also attributed the increase in damage to the higher value of damaged property and crops and was of the view that increased damage from floods does not necessarily mean increase in magnitude of floods. He was against the tendency in the country to play down the good work that had been done. He desired that the most appropriate strategy should be evolved for tackling the problem not only in the short term, but also in the long-term perspective, keeping in view the optimum development of water resources for multiple uses by storing the excess flows during the monsoon in storage reservoirs, both surface and underground. He advocated betterment levy on protected areas, especially where industries and other developmental works had come up and suggested strict regulation of the use of flood plains. He also dwelt on the need of paying greater attention to soil conservation in the catchment areas in future development and planning of flood control works.

The composition of the Ayog, notified *vide* No. FC-52(1)/76 dated 10-3-77 was as under:—

1. Shri Jaisukhlal Hathi,—*Chairman (part-time)*
2. Shri D. B. Anand,—*Member, Vice-Chairman*
3. Shri R. C. Prasad,—*Member*
4. Dr. N. Patnaik,—*Member*
5. Dr. Kamta Prasad,—*Member*
6. Member (Floods) Central Water Commission,—*Member, Ex-Officio*
7. Chairman, Ganga Flood Control Commission,—*Member, Ex-Officio*
8. Chairman, Brahmaputra Flood Control Commision,—*Member, Ex-Officio*
9. Shri K. Ramesh Rao,—*Member-Secretary.*

Shri A. N. Harkauli, Member (Designs), holding Floods as additional charge in the Central Water Commission served as *Ex-officio* Member up to 3-4-1977; his place was taken by Shri Pritam Singh, who took over as Member (Floods) in the C.W.C.

Shri R. Ghosh as Chairman Ganga Flood Control Commission and Shri H. Gohain as Chairman, Brahmaputra Flood Control Commission served as *ex-officio* Members throughout the term of the Ayog.

At his request, Shri K. Ramesh Rao, Member-Secretary was reverted to his parent department on 8th August, 1978; Shri S. Babington took over charge and continued thereafter.

On 25th December 1978, the Ayog lost Shri R. C. Prasad, Member (Engg.). The vacancy caused due to his sudden and unfortunate demise could not be filled up till June 1979 when Shri N. Sanyal, Member, Ganga Flood Control Commission took over as part-time Member (Engg.) in addition to his own duties. A list of officers of the Ayog is appended at Annexure 1.3.

1.9. Questionnaire and response

With a view to collect information on its terms of reference, a comprehensive questionnaire (Appendix I) was prepared by the Ayog and copies issued to the States/Union Territories during April/May, 1977. The States were requested to furnish the required information by September 1977. A mini-questionnaire (Appendix II) was also issued to the States/Territories of Nagaland, Arunachal Pradesh, Mizoram and Sikkim seeking information as relevant to these territories. However, there was considerable delay in receiving the information from the States. Though some information was received in 1977, bulk of the information was received only in the latter part of 1978 and early 1979. Some information from some States had not been received even upto the stage of completion of the report. Details are shown in Annexure 1.4.

Apart from the questionnaire to the States, specific questionnaires (Appendix III) were also prepared for obtaining information on important and relevant items from the Central Ministries/Departments. These questionnaires were issued during May—July 1977. Details regarding issue of the questionnaires and receipt of replies are shown in Annexure 1.5. In order to elicit views of the general public, an advertisement (Appendix IV) inviting suggestions from the public was inserted in the leading newspapers of the country in December 1977. A mini-questionnaire (Appendix V) was also sent to the Members of Parliament in January 1978. Ten Members of Parliament responded to the questionnaire and 28 persons from the public sent their suggestions; these were duly considered.

1.10. Visits

For an exchange of views, the Ayog visited the more flood-prone States of Assam, West Bengal, Orissa, Uttar Pradesh and Bihar during the month of September 1977. Visits with similar objectives were also made to the CW&PRS, Pune and States of Gujarat, Maharashtra, Haryana and Punjab during February-March 1978, and to the States of Karnataka, Tamilnadu and Kerala during December 1978. During these visits some of the flood prone areas and individual works were also inspected. Individual Members visited the States of Andhra Pradesh, Jammu & Kashmir, Madhya Pradesh, Manipur and also held discussions with the Central/autonomous organisations like Central Water & Power Research Station, Pune, the Ganga Flood Control Commission, Patna, the Damodar Valley Corporation, Calcutta and Bhakra Beas Management Board, Chandigarh.

Apart from eliciting evidence from the important States/Union Territories and Central Departments/Ministries, the Ayog arranged case-studies for the Kosi embankment in Bihar and the Puthimari embankment in Assam through the Programme Evaluation Organisation of the Planning Commission. A limited case study of the Damodar Valley Project Corporation was undertaken by the Ayog itself.

1.11. Studies of the replies and clarifications thereof

The material received in reply to the questionnaire was studied and clarifications and additional information were sought from different States. These were followed up by visits to the States of Andhra Pradesh, West Bengal and Assam in February 1979; Manipur, Uttar Pradesh, and Bihar in March 1979; and Punjab and Haryana in April 1979. During these visits, important policy matters and points needing clarifications were discussed at official level. Key issues were also discussed with Ministers of some of the States.

1.12. Discussion with experts

The Ayog also had the benefit of the views of the following experts during November 1979:—

(i) Dr. Kanwar Sain, retired Chairman, Central Water & Power Commission.

(ii) Shri B. S. Nag, Assessor, Narmada Waters Dispute Tribunal.

(iii) Shri C. C. Patel, Secretary, Department of Irrigation.

(iv) Dr. K. L. Rao, Ex-Union Minister for Irrigation & Power.

(v) Dr. M. S. Swaminathan, Secretary, Department of Agriculture.

(vi) Dr. K. C. Thomas, Chairman, Central Water Commission.

1.13. National Plan

In the preamble of the Resolution of the Government of India, constituting the Ayog, a mention has been made about a National Plan and fixing of priorities for its implementation. However, as desired in the term of reference, the Ayog has indicated an approach to the problem and suggested measures which could be implemented in different States/basins.

1.14. Meetings of the Ayog

Over the period of its life, the Ayog held 30 meetings under the Chairmanship of Shri Jaisukhlal Hathi. Apart from these formal meetings, 55 internal meetings were held amongst the Members.

1.15. Scheme of the Report

The Report has been compiled in two volumes. Volume I contains the main Report and recommendations, and Volume II. the appendices. Volume I of the Report contains 23 chapters in all dealing with one general and 11 specific terms of reference. The extra chapters deal with some allied aspects, thus resulting in fuller consideration of our terms of reference. A general survey of the Rivers of India, the incidence and extent of floods, analysis of damage data and methods of flood control have been included before taking up the chapters relevant to the terms of reference, starting with a review of the measures undertaken since 1954 in "Past Approach and Achievements". The scope of 'Land use in flood plains' has been widened to cover the entire basin so as to include the upper catchments. The term of reference No. 5 covering comprehensive approach has been dealt with under 'Future Approach'. A chapter on 'Planning and Implementation' has also been included. We have discussed the question of mobilisation of resources for flood protection measures under the Chapter titled 'Financing' dealing with the general policy of financing flood control schemes. Some additional matters related to floods and flood control have also been considered and short chapters on these have been included. They are 'Legislation for flood control'. 'Collection and Publication of Data'. 'Research, Education & Training' and 'Cyclones & Sea Erosion'. There are 9 Appendices.

1.16. Acknowledgements

The information used and the data presented and analysed in the Report are mainly as were made available by the State Governments and Central Organisations and Departments. The Ayog is indebted to the State Governments and these Organisations for their co-operation. During our visits, the States extended all courtesies and assistance to the Ayog, for which we are highly grateful.

The Ayog is grateful to the Central Water Commission and the Ganga Flood Control Commission for their ready assistance in supplying data and other relevant information from time to time. The Ayog is also grateful to the Department of Irrigation for its co-operation and assistance all along which enabled the smooth functioning of the Ayog.

The Ayog would also like to record its gratitude for the spontaneous response received from the experts who were kind enough to give us the benefit of their views.

We are also thankful to those Members of Parliament and members of the public who responded to our requests for suggestions and views.

Lastly we express our sincere thanks to the Embassies of the United States, Japan, Federal Republic of Germany and the Netherlands as well as the Canadian High Commission for precuring relevant literature on the subjects concerned from their countries and supplying the same to the Ayog. Our thanks are also due to the United Nations Development Programme, the Economic and Social Commission for Asia and the Pacific as well as the National Water Authority of Hungary for favouring us with useful literature on the subject of flood control.

ANNEXURE 1.1

Welcome speech By Shri J. L. Hathi Chairman, Rashtriya Barh Ayog, 4th December, 1976.

It gives me great pleasure to welcome you to the inaugural meeting of the Rashtriya Barh Ayog. The resolution constituting this Ayog was issued early in July. However, the formalities connected with the appointment of the Members and the setting up of the office of the Ayog could be completed only during the last month. Consequently the Ayog has started functioning only a few days ago.

The announcement of the setting up of the Ayog in July last coincided with the devastating floods in the Barak Basin in Assam and parts of Tripura. The leading articles in some of the newspapers had then made references to the constitution of this Ayog and had pointed out that in spite of the progress made during the last two decades with an investment of over Rs. 400 crores and claim by the Government that 8 million hectares had been protected, the annual damage caused by the floods had shown no signs of diminishing and in fact had increased manifolds during the last few years. It had also been mentioned that the flood control programme initiated in 1954 had not only slowed down during the last decade but adequate attention was not being paid to the proper maintenance of the works implemented. While referring to the difficult task ahead of the Ayog, they had made some suggestions for its consideration and stressed the need for effective implementation of the flood control programme initiated in 1954.

In the preamble of the resolution constituting the Ayog, it has been mentioned that during the last two decades considerable experience has been gained in planning, implementation and performance of the flood protection and control measures. Advancement in Technology has taken place not only in India but also in foreign countries. Therefore, it has become necessary to conduct a study in depth of our approach and progress of flood control measures. New policies and approach will have to be laid down after taking into account the problems concerned with flood control measures and also aspects like soil conservation measures and afforestation. This has necessitated the setting up of the Rashtriya Barh Ayog for evolving a co-ordinated, integrated and scientific approach to the flood control problem and to draw a national programme fixing priorities which could be implemented in the near future.

The terms of reference to the Ayog are comprehensive and *inter alia* include an evaluation of the benefits and effectiveness of the measures undertaken so far, assessment of the effect of the construction of Zamindari embankments on the flood problem, analysis of the damage caused by floods in recent years and identifying areas requiring immediate flood protection measures, evolving a comprehensive approach to the problem of floods in the country keeping in view the need for optimum and multipurpose utilization of water resources as also the role of soil conservation and afforestation in flood control, analysis of the cost and benefits of the flood protection measures and suggesting criteria for taking flood protection measures and means of mobilising resources therefor.

The task entrusted to the Ayog, therefore, involves the collection and analysis of the data of flood damage and flood control measures which have been implemented, the policies and approach adopted so far and the proposals for the future. The responsibility of flood control at present is primarily that of the State Governments and therefore, all the information will have to be collected from the concerned State Governments. In the resolution constituting the Ayog which has been communicated to all the States their co-operation and assistance in supplying the data and other information that may be required by the Ayog from time to time have been sought.

The Ayog is presently framing a comprehensive questionnaire for eliciting from the State Governments all relevant information and preliminary views on matters requiring discussion. This will naturally take some time and therefore we are requesting the State Governments to send preliminary memorandum on the flood and drainage problems, measures taken so far and their performance, steps that are being taken and proposed for tackling the balance problem and the view points of the State Governments on the various matters relating to the terms of reference to the Ayog.

The flood problems and measures required in different parts of the country have been studied by a number of committees during the last two decades and have also been discussed at a number of conferences and symposia. The reports and proceedings of these committees and symposia will be valuable in the deliberations of the Ayog. In due course, the Ayog will visit the States for holding discussions with the State Governments. Opportunity will then be taken to visit some of the more flood prone areas and also to hold discussions with the public to have their view points.

We are aware of the responsibility entrusted to us but we hope to discharge it satisfactorily with the co-operation of the State Governments, Central Government Departments, such as the Soil Conservation and Forestry Division in the Department of Agriculture, India Meteorological Department and the Survey of India and other organisations. The flood problem is mostly confined to the Ganga and the Brahmaputra Basins. There are special organisations, namely the Brahmaputra Flood Control Commission and the Ganga Flood Control Commission which have been set up for the planning and co-ordinated implementation of flood control measures in these two basins. These organisations as well as the Central Water Commission who co-ordinate the flood control efforts of the entire country are represented on this Ayog. The members representing these organisations will, no doubt, contribute substantially in the deliberations of the Ayog.

I now request Shri Jagjivan Ram ji to address us and give the benefit of his suggestions and advice which we could keep in view in our deliberations.

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ANNEXURE 1.2

Inaugural speech by Shri Jagjivan Ram, Union Minister of Agriculture & Irrigation, 4th December, 1976

I am very happy to be with you today for the inauguration of the Rashtriya Barh Ayog.

The Chairman has already given some background of the formation of the Commission. He has referred to the criticism in various forums about the adequacy and the efficacy of the flood control measures that have been taken so far.

There is no doubt that the reported figures of the damages caused by the floods have shown a substantial increase in recent years over the estimated damage in the earlier periods. Until about 10 years ago, the average annual damage from floods was estimated to be between Rs. 100 and Rs. 125 crores. This went up substantially in the 1971 floods and the pattern of increasing flood damage has been maintained since then.

This will lead any person straightaway to the conclusion that the measures taken for the protection of floods have failed to meet the situation. On the contrary their magnitude is increasing. There is little evidence, however, to show that the magnitude of the floods is increasing significantly since the fifties and sixties. Yet the average annual damage today is Rs. 180 crores. Partly this may be due to the fact that there is better reporting and estimation of the losses. It is also due to the much higher value of the property, including value of the agricultural crops, which are damaged. In fact, areas which were flood-prone and which have since become protected, have shown considerable development, even some degree of urbanisation. Even if we do not take into account the tendency of the States to report higher damage figures, as stated in the Report of the Sixth Finance Commission, there seems to be no doubt that the increased damage from floods does not necessarily mean an increasing magnitude of floods.

I am mentioning this because there is tendency sometimes in our country to play down every good work that has been done. The Kosi Flood Control Scheme for instance, has certainly helped in checking the movement of rivers westward and provided better protection to an area of nearly 2.5 lakh hectares which used to be ravaged by floods. Large-scale economic development has come up in this area. Some benefits have also come to the area downstream of the Damodar Valley Dams which have helped to moderate the intensity of the floods in the lower valleys. Similarly, storage reservoirs such as Hirakud, Ukai, Bhakra, Beas, Chambal dams and Nagarjunasagar have either protected some areas from floods or have reduced their intensity considerably.

I am not saying that there is a conclusive evidence to prove that the magnitude of floods in the country has not gone up or has gone down. I am merely drawing attention to the fact that any estimation of comparative damage now and in earlier times must take into account the fact that the damage is measured today at current prices as compared to the damage in earlier years which was estimated at prices prevailing at that time.

Another point to be remembered is that all the measurement of benefits of the flood protection measures in certain areas has so far been only in qualitative terms. There has been no quantitative evaluation of these benefits so far.

In the absence of such evaluation, it becomes difficult to determine the cost-benefit ratio of flood control schemes and there will continue to be controversies about the correct priority which should be given to these schemes in the development plans.

Such an evaluation should take into account direct and indirect benefits including the introduction of multiple cropping and improvements in agriculture. It should also take into consideration the widely held view that flood protection works deprive the protected areas of the benefits of silt which gets deposited on the soil during floods. If this view is correct, then the losses resulting from it should be set off against the benefits.

In fact, I wonder whether it will be possible at all to establish a cost-benefit ratio which could be completely scientific. Nevertheless, studies should be initiated so that we can get adequate data.

I have dealt at some length with this matter because flood damage is what the people are rightly concerned about and not so much with scientific calculations of magnitude.

There was a time when we could live with floods. Now, our population has increased and new areas—some of them flood-prone have to be developed not merely to accommodate the increasing population but also to realise their special economic potential which can become possible only if those areas are protected against floods.

We have had substantial experience in the planning and implementation of flood control measures. Technology also has advanced. There have been review committees also. Some of those committees went into the question either at a time when the experience was not adequate. Other committees, which were set up later, were concerned with the problem in general and qualitative terms.

The problem of floods is tremendous in our country. Therefore, I felt that it is absolutely necessary that there should be a complete review in depth of the flood control measures already undertaken or those which we have envisaged so that we are able to evolve the most appropriate strategy for tackling the problem not only in the short-term but also in the long-term perspective.

The problem is a complex one involving not only huge costs but also social and environmental considerations. Since we are a monsoon country, most of our rainfall is received in three or four months and most of that, again, is concentrated in few weeks. I am told that our rivers have to carry as much 85 to 90 per cent of the monsoon flows along with huge quantities of silt. At the same time, we experience shortages of water in other seasons. The problem of controlling floods during the monsoon, therefore, is very much linked up with the problem of storage of water which comes during the monsoon. In that way we can not only control the floods but also make more water from storage reservoirs available during the rest of the season. Nature itself provides some storage which is mostly underground. On the other hand, we can also build huge reservoirs as we have done already. Perhaps, technology can also be used to increase the flow of water into the natural underground storages.

I am mentioning this only to bring out that since our problem of flood is mainly that of the monsoon seasons, its solution is intrinsically linked with the problem of optimum development of water resources for multiple uses.

Our population is increasing. Growing industrialisation calls for vast quantities of water. The new agricultural technologies such as the use of fertilisers or high yielding varieties also call for many more times the water that was needed for traditional agriculture. We cannot, therefore, be satisfied by merely erecting huge embankments which may protect a particular area from floods but which does nothing about saving the water from going waste into the sea. Embankments will certainly be needed in specific places for specific purposes, but we should develop our water resources in such a way that we can store the monsoon water to a greater extent than we have been able to do so far, which would protect us against floods and at the same time provide water when it is needed.

Coming to the short term measures, these are often taken on the spur of the moment or without proper scientific studies and without regard to technical opinion. I do appreciate that sometimes it becomes necessary under pressure to do something quickly even when greater thought and deliberation is required. But I would suggest that thought and deliberation need not necessarily take too long. We have in our country a large number of embankments set up under the Zamindari system which are technically not very perfect in all cases. This is specially so in Northern Bihar and Eastern U.P. But there is absolutely no justification for the kind of haphazard embankments that we are setting up under the test relief works programme. These have created a number of problems. We must assess the utility of these embankments and wherever required improve them. In any case, they must be integrated into the overall flood control plan for the area. I have been equally disturbed by the tendency towards lack of proper maintenance of the existing flood control works and the failure to strengthen them in the light of experience. One must not forget that wherever any area is protected by floods, a rapid economic growth including infra-structural growth takes place. If maintenance and improvement are ignored, the damage as a result of floods is much more than in the earlier years.

State Governments often give the reason of paucity of funds for inadequate maintenance. Yet, one finds new protection works being taken up. There is really no reason why the completed works should not be maintained efficiently. I would suggest that the Commission examine the aspect of maintenance and improvement as an integral part of the planning of flood control measures.

It will not be out of place to draw attention to some aspects which are likely to generate resources. While on the one hand complaints are made of paucity of funds, no attempts are made to raise resources through the well tried method of betterment charges in the protected areas. I agree that the areas which receive the floods frequently are poor areas and it may not be possible for the people to start paying betterment charges as soon as a flood protection work is completed. However, there is no reason why this state of affairs should be allowed to continue indefinitely. But it is not only poor who benefit from flood protection. Industries come up, many other businesses also develop in these areas. Surely, it should be possible for the people to contribute to flood control works. The burden should be equitably distributed. Perhaps, the betterment charges may be a graded one according to the capacity of the beneficiaries to pay.

It is also noticed that some of the State Governments do not take adequate measures to stop encroachment in the flood plains of the rivers. This is absolutely imperative. Otherwise it may lead to serious problems in the planning and maintenance of flood protection works. I would suggest that there should be strict regulation of the use of flood plains from now onwards.

Our biggest problem is in the Ganga and Brahmaputra basins. Measures taken so far have largely been in the form of embankments. However, these areas continue to be affected by serious floods and the utility of embankments has been questioned. An ideal solution should be combination of reservoirs and embankments which should also be supplemented by river training in the lower regions.

In our Brahmaputra basin, there are several sites for dams but the steep slopes of the rivers call for very high dams. The feasibility of constructing such high dams in an area which is highly seismic will require detailed study. But I feel that the spirit with which we should approach these problems is not one of despair. In fact the technology of reservoir construction has advanced considerably and we have some of the best experts in India. Let us not therefore consider the problem insurmountable.

In the Ganga basin however, most of the rivers, which cause floods have their origin in Nepal. Moreover, preliminary studies have indicated that storage reservoirs only for the purposes of flood control may prove to be uneconomic. We have to explore the possibility of multipurpose reservoirs for the mutual benefit of both our countries.

But the planning and implementation of reservoirs takes a long time. In the meanwhile, we have to provide relief from recurring floods. I would suggest that a detailed study of the embankment system in the Ganga and Bhahamaputra basins should be made in order to improve the situation.

There has been much talk recently of soil conservation and the contribution that such measures can make in controlling floods. Confining mostly for the present only to the question of flood prevention, I would say that even if the role of soil conservation measures in high floods may be questionable, there is no doubt that these would help in reducing flood peaks and the flow of silt into the rivers. At the same time, we know that the upper reaches of the rivers in Brahmaputra valley are thickly forested; yet the mountains slopes are unstable leading to many landslides. The nature of measures to be taken in this valley therefore have to be different. In so far as the northern tributaries of the Ganga are concerned, the Upper catchments lie mostly in Nepal. We have to think of this limitation when we talk of using soil conservation in the upper reaches of rivers in a big way to reduce floods. Yet much can be done in other areas and great attention should be paid to soil conservation in future development planning.

Yet another aspect that we have to bear in mind is that of environment. The possible negative effects from the environmental point of view have to be studied. Flood protection measures in the long run should be so devised as to minimise the possible negative effects.

I am particularly happy that Shri Jaisukhlal Hathi has been kind enough to agree to be the Chairman of this Commission. He has recently assumed the office of Governor. I am grateful to him for agreeing to my suggestion that he may continue to be the Chairman in spite of his many other onerous responsibilities. His vast experience of administration and his understanding of the development process will no doubt enable the Commission to view the problem of flood control in the larger perspective of the development of our water resources in a scientific manner.

I am sure that, given the dynamism of the Chairman and the Members, the Commission will indeed be able to prepare its report and a National Plan for flood control at the earliest since the problem is urgent. We must never forget that what we are dealing with is something that has been and continues to be a cause of great human misery. We must think of the vast number of people who every year lose their lives or property in floods. The rural poor particularly have no reserves. Their homes are such that they easily collapse. They lose their property and goods, they lose such little capital as they may have and they lose the crop which alone could give them sustenance. Thousands perish and thousands—may be hundreds of thousands—are overnight thrown into a life of penury from which they take a long time to recover. The Commission must keep this perspective in view.

The problems are very complex. That is why we have made the terms of reference of this Commission as wide as possible. The Commission also has the advantage of having on it some of our best technical experts on the subject. I am sure the Commission will perform its task to the satisfaction of all concerned. I wish the Commission all success.

ANNEXURE 1.3

List of Officers of Rashtriya Barh Ayog

Sl. No.	Name & Designation	From	To
	I. *Technical*		
1	Shri O. P. Kumra, Director	15-1-1977	To-date
2	Shri K. U. Tirthani, Dy. Director (Engg. I) . . .	24-1-1977	To-date
3	Shri James Kurian, Dy. Director (Eco.)	1-11-1977	To-date
4	Shri M. L. Baweja, Dy. Director (Engg. II)	28-12-1977	To-date
5	Shri V. V. Jetley, Dy. Director (Eva. I)	9-10-1978 (A.N.)	1-2-1980
6	Shri B. Kaul, Dy. Director (Eva. II)	2-6-1979 (A.N.)	31-12-1979 (A.N.)
	II. *Administrative*		
1	Shri O. P. Nayar, Under Secretary	1-9-1976	19-12-1977
2	Shri A. S. Gill, Under Secretary.	15-7-1978 (A.N.)	16-10-1978
3	Shri T. D. Joshi, Under Secretary	16-10-1978	To-date
4	Shri T. C. Mehta, PS to Chairman	3-9-1977	To-date
5	Shri H. S. Pawar Section Officer	1-6-1977	To-date
6	Shri A. H. Venkatachalam, SPA	9-12-1976	To-date
7	Shri K. S. Rajagopalan SPA	23-12-1976	28-2-1978 (A.N.)
8	Shri K. D. Gandhi SPA	24-12-1976 (A.N.)	To-date
9	Shri U. Krishnamurthy SPA	28-12-1976	24-1-1977
10	Shri K. S. Kaushik SPA	31-12-1976	To-date
11	Shri C. L. Sharma SPA	24-1-1977	To-date
12	Shri M. S. Mehta SPA	14-4-1978	1-7-1978
13	Shri Pran Nath SPA	1-7-1978	To-date

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ANNEXURE 1.4

Dates of issue and receipt of replies in respect of Questionnaire to the States as on 31-1-1980.

Sl. No.	Name of State/Union Territory	Date of issue of Questionnaire	Date of receipt of last replies
1	Andhra Pradesh . . .	30-4-1977	8-8-1978
2	Arunachal Pradesh . .	28-11-1978	Reply awaited
3	Assam	30-4-1977	10-8-1978
4	Bihar	2-5-1977	23-1-1979
5	Delhi . .	7-5-1977	23-1-1979
6	Gujarat	5-5-1977	26-6-1978
7	Goa, Daman & Diu . .	5-5-1977	29-10-1977
8	Haryana	4-5-1977	16-5-1978
9	Himachal Pradesh . .	8-5-1977	4-4-1978*
10	Jammu & Kashmir . .	5-5-1977	27-3-1978
11	Karnataka	8-5-1977	13-2-1979
12	Kerala	8-5-1977	18-12-1978
13	Madhya Pradesh . . .	8-6-1977	31-1-1978
14	Maharashtra	4-5-1977	25-7-1978
15	Manipur	5-5-1977	24-8-1978
16	Meghalaya	5-5-1977	Reply awaited
17	Mizoram	28-11-1978	6-3-1979@
18	Nagaland . .	28-11-1978	Reply awaited
19	Punjab	8-5-1977	8-11-1978
20	Orissa	30-4-1977	19-11-1977
21	Rajasthan	4-5-1977	26-5-1979
22	Sikkim	13-12-1979	Reply awaited
23	Tamil Nadu	5-5-1977	2-1-1979
24	Tripura	5-5-1977	14-8-1978**
25	Uttar Pradesh	2-5-1977	27-2-1978
26	West Bengal	30-4-1977	8-8-1978

*Information pertaining to Public Works Deptt. reply.

**Partial replies of some terms of reference only.

@Nil information intimated.

ANNEXURE 1.5

Statement showing the dates of issue and receipt of replies in respect of Questionnaire to Central Organisation/Departments

Sl. No.	Name of Central Organisation	Date of issue of Questionnarie	Date of receipt of last replies
1	Central Water Commission .	21-6-1977	6-4-1978
2	Central Water & Power Research Station	18-7-1977	23-12-1977
3	Department of Agriculture .	25-7-1977	26-8-1978
4	Department of Agricultural Research and Education .	25-7-1977	16-2-1978
5	Department of Irrigation	11-7-1977	9-3-1979
6	Ganga Flood Control Commission	27-6-1977	29-5-1978
7	India Meteorological Deptt. .	14-7-1977	30-11-1977
8	Ministry of Shipping and Transport	27-6-1977	21-6-1979
9	Planning Commission . .	16-7-1977	24-12-1977
10	Railway Board . . .	31-5-1977	12-6-1978
11	Border Roads Organisation .	17-9-1977	13-7-1979
12	Survey of India . . .	17-9-1977	28-10-1977
13	Geological Survey of India .	17-9-1977	17-7-1979

II RIVERS OF INDIA

2.1. Introduction

A river is a definite channel developed over the ages draining its basin of precipitation and snowmelt. Our country is fortunate in that numerous rivers—big and small—traverse the land in practically every direction carrying much needed water through dry and thirsty lands before they empty themselves into the sea.

2.2. Legend of the Indian rivers

As elsewhere, the growth of tribal settlements and mighty kingdoms, prosperous towns and fertile villages, religious shrines and peaceful hermitages can be traced along the banks of our rivers and in close proximity to them. Markendeya purana says, "All the rivers are sacred, all flow towards the sea. All are like mothers to the world, all purge away sins". The Rig Veda, the Raghu Vamsa and most other ancient scriptures have sacred references to the different rivers. It is, therefore natural that religious significance is attached to towns like Hardwar, Mathura, Varanasi etc., on the main rivers and Allahabad at the confluence of rivers. The Hindu mythology is replete with exploits of warriors and hermits on the banks of these sacred rivers.

The mighty rivers of India that flow from the great mountain barrier into the plains of India attracted Jawaharlal Nehru and reminded him of the innumerable phases of our history. In "The Discovery of India', he writes: "The Indus or Sindhu, from which our country came to be called India and Hindustan, and across which races and tribes and caravans and armies have come for thousands of years; the Brahmaputra, rather cut off from the main current of history, but living in old story, forcing its way into India through deep chasms cut in the heart of the north-eastern mountains, and then flowing calmly in a gracious sweep between mountain and wooded plain; the Yamuna, round which cluster so many legends of dance and fun and play; and the Ganga, above all the River of India, which has held India's heart captive and drawn uncounted millions to her banks since the dawn of history. The story of the Ganga from her source to the sea, from old times to new, is the story of India's civilization and culture, of the rise and fall of man and the quest of the mind which has so occupied India's thinkers, of the richness and fulfilment of life as well as its denial and renunciation, of ups and downs, of growth and decay, of life and death."

2.3. The river course

Usually, a river traverses three types of topography *viz.*, the upper reach in the hilly regions, the middle reach in the alluvial plains and the deltaic/estuarine reach near its outfall into the sea.

2.3.1. *The upper reaches*

These can be of two types *viz.*, 'incised' and 'boulder'. The incised rivers have well-defined banks which are resistant to erosion. The bed of the river is also resistant to erosion in spite of the steepness of the slope and the swiftness of the current.

The boulder rivers are also characterised by steep slopes, but the beds consist of a mixture of boulders, gravel, shingle and sands. The boulder rivers tend to have straight courses with wide shallow beds. At the time of floods, the high velocity flow moves boulders and gravel downstream. But when the floods subside and the flow slackens, bed materials pile up in heaps. The flow channels with reduced velocity are unable to move these heaps and so trying to go round them, tend to wander in new directions attacking the banks and widening the bed thereby.

2.3.2. *The middle reach*

Rivers in the middle reaches are usually in the alluvial plains. These have the characteristic of meandering freely from one bank to the other on account of the erodible nature of the beds and banks. These rivers are classified as aggrading, degrading or stable rivers. If it is building up its bed, it is called an aggrading river. If its bed is getting scoured, it is callad a degrading river. If river carries down sediments which it receives without either depositing the silt or scouring the bed, it is called a stable river.

It is pertinent to point out here that, depending on the silt load and the discharge, the same river may exhibit characteristics of an aggrading, degrading or stable river in different reaches.

2.3.3. *Estuarine/Deltiac reach*

In its last reach, before its outfall into another river or sea, the river may be called estuarine. In the latter case, periodic changes in water levels occur due to tides and, therefore, in this reach, it is called a tidal river. Here, sea water enters the river with the high tide and empties out with the ebb tide. The distance up to which the tidal effect is felt depends upon the slope of the river, the tidal range, the flood discharge, configuration of the river, etc. Near its outrall to the sea, such a river is called a deltaic/estuarine river. In this reach, it is distinguished by the many branches the parent river has thrown as it approaches the sea.

2.4. Types of rivers

A river is termed 'flashy' if floods in the river rise and fall in a very short period of time. Such rivers are common in the States of Andhra Pradesh, Tamilnadu and Rajasthan.

A 'virgin' river is one which completely dries up before its outfall into the sea or another river. These are common in desert areas like the Kutch and Rajasthan where due to percolation and evaporational losses, the river disappears after flowing some distance from the source.

A river is said to meander when it adopts a tortuous course, swinging from one side to another in alternating bends.

A river is said to be braided when the bed becomes wide and shallow, with the flow composed of many interlaced channels, causing numerous islands and bars of silt deposits in the bed of the river. Within its 'Khadir'* however, it adopts a fairly straight course. Generally, a meandering river gradually turns into a braided river, especially, when it approaches the sea.

2.4.1. *Classification of rivers*

The major river systems in the country can be broadly classified into two groups *viz.*, rivers of the Himalayan region and rivers of peninsular India. The Himalayan rivers are fed by the melting snows and glaciers of the great Himalayan range during spring and summer, and also from rains during monsoon. They are often uncertain and capricious in their behaviour. They carry significant flows during the dry weather due to snow melt and carry minimum flows, during winter. On the other hand, the peninsular rivers originate at much lower altitudes, flow through more stable areas and are more predictable in their behaviour. Their flow is characterised by heavy discharges during the monsoon followed by very low discharges during the rainless months.

From the point of view of the flood problem, the rivers can also be grouped under the four regions as below:—

(1) Brahmaputra region;

(2) Ganga region;

(3) Northwest region;

(4) Central India & Deccan region.

A map of India showing these rivers and their basins is enclosed.

2.5. Brahmaputra region

This region consists of the rivers Brahmaputra and Barak and their tributaries and covers the States of Assam, Meghalaya, Manipur, Tripura and Nagaland, northern portions of West Bengal and the Union territories of Arunachal Pradesh and Mizoram.

2.5.1. *The Brahmaputra*

The Brahmaputra (son of Brahma) rises just south of the lake Konggyu Tsho in Tibet, very near the Manasarover lake at an elevation of 5150 metres. The Mariam la pass separates the catchment of Brahmaputra and the Manasarover lake from which Indus and Sutlej originate. The river under its Tibetan name of Tsang po flows through southern Tibet for about 1700 km eastwards and parallel to the main range of the Himalayas. In this reach it receives the waters of important tributaries Raga Tsangpo, Ngang chu, Kyichu, and Griamda chu. Beyond Pe (3000 m) the river abruptly turns to the north and flows in a succession of rapids between the high mountains of Gyala Pari and Namcha Barua (7756 m) and turns to the south and south-west to emerge from the foothills of Arunachal Pradesh first under the name of Siang and then as the Dihang. Flowing southwards it enters the Assam valley, west of Sadiya town where two important tributaries, the Debong and Luhit join the river. Thereafter, it is known as the Brahmaputra. The mighty river then rolls down the Assam valley from east to west for a distance of about 720 km, its many channels meandering from side to side and forming numerous braids creating many islands. In this reach it receives from the north the Jiadhal, the Subansiri, the Kameng, the Dhansri, the Puthimari, the Pagladiya, the Manas, the Champamati, the Saralbhanga and the Sankosh. The important south bank tributaries are the Noa Dihing, the Burhi Dihing, the Disang, the Dikhu, the Jhanji, the Dansiri (south) and the Kopili. Thereafter the river swings round the spurs of the Garo hills near Golpara and enters Bangladesh. There are some important tributaries flowing through North Bengal and joining Brahmaputra in Bangladesh. They are the Tista, the Jaldhaka, the Torsa, the Kalyani and Raidok. The Brahmaputra then flows southwards for a distance of about 250 km before joing the Ganga at Golundo. The united streams of Bramaputra and the Ganga flow in the name of Padma for about 105 km when the main stream is joined on the left bank by another large river, the Meghna, with its source in the high mountains of Assam. From this confluence onward, the river known as Meghna splits into a broad estuary before falling into the Bay of Bengal. The Brahmaputra in its entire length both in India and Bangladesh is braided consisting of several channels except in stretches where confined by natural constrictions. The behaviour of the Brahmaputra is quite complex in nature. Both banks of the river are under stress and subjected to acute erosive activity of the river. The specific yield of the river is the highest amongst the big rivers of the world.

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*Low alluvial land on either side of the river.

The tributaries of the Brahmaputra have widely divergent characteristics. The characteristics of the north bank tributaries are:

(1) they have very steep slopes and shallow braided channels;

(2) they have coarse sandy beds and carry heavy silt charge;

(3) they bring flashy floods because of the short distances between their source in the hills and the confluence.

The characteristics of the south bank tributaries on the other hand are:

(1) they have comparatively flatter grades and deep channels right from the foothills;

(2) the beds and banks are composed of more clayey component; hence more stable.

(3) they carry a comparatively low silt charge.

Major tributaries of Brahmaputra

(i) *The Subansiri*

The Subansiri rises in the mountains of Tibet. It is known as Sukanchoo near the source. It changes its name to Niyichoo and flows past the Karutra temple. A little more than 40 km further downstream it receives Tsari chu and the combined waters assume the name of Subansiri. After travelling from its main source for a distance of about 273 km it enters the Miri hills. After piercing through the Miri hills, it flows through a narrow gorge. After 8 km, it emerges from the hills through short canyons into the plains. Leaving the hills near Dulungmukh, the river flows through the fertile plains of the north Lakhimpur Civil Sub-Division. After flowing about 97 km from the hills, it meets the Kherkutia-Suti, a spill channel of the Brahmaputra and changes its name to Lohit. The total length of the Subansiri is about 442 km. out of which 192 km lie in Arunachal Pradesh and 100 km in Assam.

(ii) *The Kameng*

The Kameng rises in Tibet beyond the Aka and Dalla hills of Himalayas. It flows for more than 193 km in the hills within the Indian territory mainly through the Kameng district of Arunachal and enters the plains near Bhalukpung. After leaving the hills near Bhalukpung, the river first flows east between two ranges of low hills and then turning sharply to south follows a tortuous course to the Brahmaputra which it joins at about 11 km east of Tezpur town. The total length of the river is 264 km out of which 198 km are in Arunachal and 66 km in Assam. Very little is known about this river in its upper reaches as the valley is covered with dense vegetation and impenetrable forests.

(iii) *The Manas*

The Manas is formed by the confluence of the Tongsa and the Kur which rise from the great Himalayan ranges near the village of Sufali, a few kilometres inside Bhutan. From Sufali, the river Manas flows in a north-south direction for about 8 km. and enters the Kamrup district of Assam. After flowing in a generally south-westerly direction for about 29 km the river enters the Goalpara district. From the village of Agrong, it follows a serpentine course for about 75 km and outfalls into the Brahmaputra near Jogigopa. En route, it is joined by the river Ai which rises in the Black mountains at an altitude of about 4915 m near the village of Bangpari. The Ai is about 110 km. in length and the total length of the Manas measured along its longest tributory the Kur is 376 km out of which about 104 km lie in India.

(iv) *The Burhi Dihing*

The Burhi Dihing is formed by the confluence of the Namphuk and the Namchik which rise from the Patkai ranges and the Maganton river which is the southern branch of the Noa Dihing. The Namphuk which is considered the principal source of the Burhi Dihing rises in the Yapawp Bum ranges at an altitude of 2300 m and flows in a westerly direction through the hills covered with dense semi-tropical forest for a distance of 116 km till it meets the Namchik river. The combined flow travels for about 16 km before it meets the Magantan river, a southern branch of the Noa Dihing river, when it assumes the name of Burhi Dihing. The Namchik river has also its source in the Patkai Bum range at an altitude of 2264 m and flows in a north-easterly direction through the hills covered with dense forests for a distance of about 64 km when it meets the Namphuk. The combined flows of

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the Namphuk-Namchik and the Meganton traverse south-west in a serpentine course for 40 km before meeting the major tributary Tirap near Ledo the centre of the coal mining area in Assam. The Tirap has its origin in the northern slope of the Patkai range at an altitude of 2780 m and flows towards the north east through gorges for about 113 km and then turns west and meanders along its course in plains for about 24 km joining the main river the Burhi Dihing near Ledo. From its confluence with the Tirap, the river Burhi Dihing moves towards the south and emerges in the hills near Margherita flowing through the fertile and prosperous plains of the Lakhimpur district. Several streams meet the Burhi Dihing during its journey through the plains of Lakhimpur. Its course has sharp curves and loops till it reaches the Brahmaputra, 32 km downstream of Dibrugarh town. The total length of Burhi Dihing is 362 km along the Namphuk river.

(v) *The Dhansiri*

The Dhansiri rises in the south-west corner of Nagaland below Laishiang peak. For the first 37 km from the source, the river flows in north-westerly direction whereafter turning to the north-east, it flows for about 76 km up to Dimapur. Beyond Dimapur, the direction of flow is generally northerly up to Golaghat where the river takes an abrupt turn and flows west ultimately to join the Brahmaputra near Dhansirimukh opposite to Majuli. From its source up to Dimapur, the Dhansiri forms the boundary between the districts of Cachar, Nowgong and Nagaland. After Dimapur, the river enters the Sibsagar district of Assam and flows throughout in the district up to its confluence with the Brahmaputra. The main tributaries of the river on the right bank are the Diyung, the Diphu, the Bhogdoi and those on the left are the Nambar, the Doigrung and the Kalyani. The total length of the river from its source up to its confluence with the Brahmaputra is approximately 354 km.

(vi) *The Kopili*

The Kopili rises near the Malangha village in the Mikir and north Cachar Hills district of Assam State and flows in a generally north-westerly direction for about 60 km along the border of the Khasi and Jaintia Hills of Meghalaya and the Mikir and north Cachar districts of Assam. Nine km. west of Lohang village, it takes a turn and flows in a generally north-easterly direction for 60 km where it is joined by Diyung. Thereafter, it takes a north-westerly direction for 67 km where it receives Jamuna, a major tributary near the town of Jamunamukh. It then turns west and flows for about 70 km. crosses the Gauhati-Tezpur railway line and after another 4 km further down, it falls into the Kalang on its left bank, which after flowing for 37 km ultimately joins the Brahmaputra near Raja Mayang. Its total length is 256 km of which 78 km form a common border of Meghalaya and Assam and the remaining 178 km lie in Assam.

(vii) *The Tista*

The Tista is the largest of the rivers of North Bengal. It rises in the Himalayas in North Sikkim. After flowing through narrow gorges for nearly 138 km in a southerly direction, it enters the plains of the Jalpaiguri district at Sivok. At this place, it turns south-east and flows in a steady course up to Jalpaiguri town beyond which it changes its course frequently. The important tributaries of the Tista are the Ramgiri, the Rangpo, the Great Ranjit, the Rali, the Lish, the Gish and the Chel. After traversing a length of 309 km, Tista joins the Brahmaputra in Rangpur in Bangladesh.

(viii) *The Jaldhaka*

The Jaldhaka also has its origin in Sikkim. It travels a total distance of 186 km passing through Bhutan, Darjeeling, Jalpaiguri and Cooch-Behar districts of West Bengal, and Bangladesh till it falls into the Brahmaputra near Alipur in the Rangpur district.

(ix) *The Torsa*

The Torsa rises in the Chumbi Valley of Tibet where it is called the Machu. After traversing through the Tibetan territory for about 113 km., it courses through Bhutan for a length of 145 km. known as the Amochu and enters the Jaipaiguri district of West Bengal above Tetapara. The river travels for a distance of nearly 100 km. in North Bengal before joining the Brahmaputra. Its main tributaries are the Holang, the Gargaria, the Kaljani, the Raidak and the Sankosh.

2.5.2. *The Barak*

The Barak rises in the Manipur hills south of Mau on the Kohima-Imphal road and flows in a south-westerly direction through a narrow valley up to Hipaimukh where it takes a complete turn and flows north up to Jirighat. It then travels west and emerges from the hills, a few km. above Lakhipur. On emerging from the hills, it traverses the valley in a westerly direction to Bhanga, a few km. below Badarpur where it bifurcates into two branches—the Surma and the Kushiara. The border of the Cachar district of Assam lies along the eastern bank of the Surma and along the southern bank of Kushiara up to a point 32 km. west of this bifurcation point. The length of the river from its origin up to Lakhipur is 403 km., up to the border of Assam along the Kushiara it is 564 km. and up to its out-fall into Meghna near Bairab Bazar in Bangladesh, it is 902 km. Its important tributaries are the Jiri, the Chiri, the Horong, the Katakhal and the Longoi.

2.5.3. *The Gumti*

The Gumti rises in the hills of Tripura and is formed by the confluence of two streams the

Surma and the Rajma at Ducharibari. It flows throughout in a westerly direction in a well defined course. After passing through Rangamati, Sonamura and Durgapur towns, it crosses the international boundary and joins the Meghna in Bangladesh. The other important rivers lowing through Tirpura are the Hoara, the Manu, the Khowai and Muhari.

2.5.4. *The Imphal*

The Imphal drains a basin adjacent to the Brahmaputra basin. It rises in North Manipur and flows through Imphal town, the capital of Manipur. It receives the Iril from the south and Thoubal from the east. It also receives the Khuga from the south-west. The big Loktak lake situated in the heart of the Manipur valley drains into the Imphal river through the Kordak river and the Imphal river is known as the Manipur river below its confluence with the Kordak river. Three km below Sugnu, the river is joined by the Chakpi river flowing from the opposite direction. The combined waters flow south-ward through a narrow gorge in the southern hilly part of Manipur and then traverse down to fall into the Chindwin river of Burma. Another small local river Nambul flows into the Loktak lake.

2.6. Ganga Region

This river region consists of the river Ganga and ist numerous tributaries. It covers the States of Uttar Pradesh, Bihar, south and central portions of West Bengal and parts of Haryana, Himachal Pradesh, Rajasthan and Madhya Pradesh and the Union territory of Delhi.

(i) *The Ganga*

It may be a revelation to many that the Ganga is not known by this name either at its source or its mouth. In its initial stage, up to Devaprayag, the river is known as Bhagirathi. At Devaparyag, another hilly stream the Alaknanda joins it; from this point, the combined stream is known as Ganga. Bhagirathi rises at the Gangotri glaciers in the Uttar Kashi district at an elevation of 7016 m. After flowing nearly 250 km through hilly terrain, the Ganga debouches into the plains at Rishikesh. Thirty km below Rishikesh is Hardwar, a religious centre. Beyond Hardwar, the river flows over the fertile plains of Uttar Pradesh and receives the Ramganga before touching Allahabad. At Allahabad, it is joined by the Yamuna on its right bank. The Chambal, the Betwa and the Ken are the principal streams flowing into the Yamuna and they drain considerable areas of Madhya Pradesh. After Allahabad, the river sweeps for another 245 km to Varanasi, a well known pilgrim centre during which course, it receives the Tons from the south. The Gomti joins it immediately below Varanasi.

The Ganga enters Bihar in the middle region, 155 km from Varanasi. In this region, it receives from the north the very important tributaries of the Ghaghra at Chapra, the Gandak near Patna, the Burhi Gandak opposite Monghyr and the Kosi at Kursela. From the south it is joined by the Karamnasa near Chanusa, the Sone near Koelwar and Pun Pun 25 km east of Patna. The river enters West Bengal in the lower Ganga basin, swings round the Rajmahal hill range opposite Manihari Ghat and starts flowing almost due south. The delta of the Ganga can be said to start from Farakka in West Bengal. The river divides itself into two arms about 40 km below Farakka. The left arm called the Padma flows eastward into Bangladesh while the right arm of the river called the Bhagirathi continues to flow south in West Bengal. The Mahananda from the Darjeeling district branches into two arms; the right arm joins the Ganga upstream of Farakka and the left arm flow into the Padma soon after the latter enters Bangladesh. The Padma flows in a south-easterly direction and is joined by the Brahmaputra first and then the Meghna. Later, the river divides and subdivides into a number of channels all of which ultimately wend their way into the Bay of Bengal.

The Bhagirathi flowing south in West Bengal divides the Murshidabad district into two and then forms the eastern boundary of the Burdwan district. In this reach it is joined by two right bank tributaries viz., the Dwarka and the Ajay. The Bhagirathi receives the Jalangi just above Nabadwip town (a spill channel of the Padma taking off about 15 km below the take off point of the Bhagirathi). After its confluence with the Jalangi, the Bhagirathi is known as the Hooghly and it forms the boundary of the Hooghly and the 24 Parganas districts. Calcutta, the biggest Indian city stands on the Hooghly. The Hooghly receives a left bank tributary, the Bagherkal just upstream of Calcutta. Below Calcutta the river first flows south-west, then nearly due west and south-west as far as Achipur. It then flows almost due south and receives the Damodar on its right bank. Immediately downstream it receives the Rupnarayan also on its right. These two tributaries have set up in the river the dreaded moving shoals known as the James & Mary islands which make navigation in Hooghly difficult. After Diamond Harbour the river resumes a southerly direction until it debouches into the Bay of Bengal. The mouth of the river at its junction with the sea is about 25 km wide. Shortly before its outfall into the Bay, the river divides into two arms on either side of the Sagar Island. The right channel receives the Haldi river in the Midnapore district.

The total length of the Ganga from its source to its outfall into the sea measured along the Bhagirathi and the Hooghly is 2525 km of which 1450 km lie in Uttar Pradesh, 110 km along the U.P.- Bihar border, 445 km in Bihar and 520 km in West Bengal.

The Ganga has a number of tributaries which are important rivers by themselves. They are the Ramganga, the Yamuna, the Tons, the Gomti, the Ghaghara, the Sone, the Gandak, the Pun-Pun, the Kiul, the Burhi Gandak, the Kosi and the Mahananda. The major tributaries of the Bhagirathi-Hooghly, arms of the Ganga, are the Dwarka, the Ajay, the Damodar, Dwarakeshwari/Rup Narayan and the Haldi.

(ii) *The Ram-ganga*

The Ram-ganga is the first major tributary of the Ganga to join it on its left bank. Its total length from the source to outfall into the Ganga is 596 km. It rises at an altitude of about 3110 m in the lower Himalayas near the village of Lohba in the Garhwal district of Uttar Pradesh. After flowing in a south-easterly direction for about 32 km., it flows in a south-westerly direction successively through Almora and Garhwal districts for about 112 km. During its course in these districts, the river flows through mountainous terrain and has a number of falls and rapids. The river emerges from the hills into the plains at Kalagarh near the border of Garhwal district. Beyond Kalagarh, the river flows in a south-easterly direction and finally joins the Ganga near about Kanauj in the Fategarh district. The river flows entirely in the State of Uttar Pradesh.

(iii) *The Yamuna*

The Yamuna is the most important tributary of Ganga and joins it on the right bank. It rises at the Yamunotri glacier in Tehri-Garhwal district of U.P. at an elevation of 6330 m. The river forms the common boundary between Haryana and Uttar Pradesh for 320 km., flows through the Union territory of Delhi for 40 km. and the balance 970 km. through Uttar Pradesh. The Tons, the largest Himalayan tributary of the Yamuna joins it below Kalsi. The Giri, another mountainous tributary rises near Simla and joins the Yamuna near Paonta. The Yamuna emerges from the hills near Tajewala. From Faizabad, the river flows for a distance of 104 km. in a north-westerly direction. Near Bidauli in the Muzaffarnagar district, Uttar Pradesh, it turns to the south for 120 km. and reaches Delhi. At Delhi, the Sahibi waters flow into the Yamuna through the Najafgarh drain. Beyond Delhi, the Yamuna continues to flow south as far as Mathura—a distance of 203 km. The Hindon river joins the Yamuna on its left bank at Dankaur. From Mathura onwards, the river flows in a south-westerly direction through Agra, Mainpuri, Etah, Kanpur and Allahabad districts before joining the Ganga near Allahabad city. During its course through these districts, it is joined on its left bank by some small tributaries *viz.*, the Karon, the Sanger and the Rind. The Chambal, the Sindh, the Betwa, the Dhasan and the Ken join the river on its right bank. All the right bank tributaries have their origin in the Vindhyas. Its total length from the source to its outfall into the Ganga is 1376 km.

(iii) (a) *Sahibi river*

The Sahibi river rises from the hills of Bairath near village Barijori about 8 km. north-west of Shapura in Jaipur district of Rajasthan. After flowing in a north-easterly direction for a length of 145 km. in Rajasthan it enters Haryana State beyond Kot Qasim. One of its major tributaries in Rajasthan joining it on its left bank at the 88th km. is Sota. It has only right bank tributaries other than Sota. These are Babania and Kot Qasim in Rajasthan and the Indori nala in Haryana. The river crosses the Delhi Alwar railway line at Ajarka and the National Highway No. 8 of Gurgaon-Rewari road near Masani. The river has a defined course only upto a small distance downstream of Masani. Thereafter there is no defined course. As per the Survey of India maps, the indication is that this river along with similar other rivers in Rajasthan like the Luni, disappear in the sandy tracts. However, it has now been recognised that the Sahibi waters flow more or less in sheet flows from West to east *i.e.* from Haryana towards Delhi and enter Delhi territory through Dhansa Bund; after discharging into the Najafgarh jheel, the Sahibi waters flow into the Yamuna through the existing Najafgarh drain in Delhi.

(iii) (b) *The Chambal*

The most important tributary of the Yamuna is the Chambal which is 960 km. long and rises at an elevation of 854 m in the Vindhya range near Mhow in the Indore district of Madhya Pradesh. It flows in a generally northerly direction for a length of 320 km. up to the Madhya Pradesh-Rajasthan border. It then enters Rajasthan and after flowing for a length of 30 km., turns to the right and takes a north-easterly course. After flowing 520 km. in a north-easterly course during which it receives the Kali Sind and the Kural, the river forms a common boundary between Madhya Pradesh and Rajasthan for a length of 251 km. In this reach, the Banas, a major left bank tributary joins the Chambal near the village of Rameshwar. The river then forms a common boundary between Madhya Pradesh and Uttar Pradesh for 117 km. and flows in a north-easterly direction up to the village of Pinahat when it turns right and flows in a south-easterly direction to enter Uttar Pradesh. After flowing for 46 km. in Uttar Pradesh, the Chambal outfalls into the Yamuna, south-east of the village of Sahon in the Etawah district.

(iv) *The Tons*

The Tons river rises at Tamaskund, a tank in the Kaimur range of hills in the Satna district of Madhya Pradesh at an elevation of 610 m. The river flows first in a north-easterly direction for about 192 km. and after traversing the rough hilly country round Maihar, flows through the fertile land of Rewa and Satna districts. Near Satna town it receives the Satna and lower down the Bihar and Chachai. As the river crosses the Purwa plateau the river and its tributaries form a series of water falls. It enters Uttar Pradesh at Deoria and after receiving the Belan, a major tributary on its right, flows to join the Ganga about 31 km. downstream of the confluence of the Ganga and the Yamuna. The river has a total length of about 264 km. of which 202 km. are in the Madhya Pradesh and the balance of 62 in Uttar Pradesh.

(v) *The Gomti*

The Gomti rises near Mainkot about 3 km. east of Pilibhit town in the Pilibhit district of Uttar Pradesh at an elevation of 200 m and drains the area lying between Ram-ganga and Sarda in the upper reaches and lower down the area between the Ganga and the Ghaghra. It flows through Shahjahanpur district and then through Kheri and Lucknow districts in the south and south-easterly direction passing through Lucknow town. Beyond Lucknow district, the river flows through the districts of Barabanki, Sultanpur, Faizabad and Jaunpur and finally forms a boundary between Varanasi and Ghazipur districts before its confluence with the Ganga. The total length of the river is about 940 km. entirely in the State of Uttar Pradesh.

(vi) *The Ghaghra*

The Ghaghra, known as Manchu and Karnali in Nepal, has its source near lake Mansarover, at an elevation of 4800 m. After flowing for about 72 km., in a south-easterly direction, the river enters Nepal territory. The river continues its serpentine course, receives the Mugu Karnali and the Tiha and winds its way till Churighat whereafter it takes almost a westerly course till it reaches Dundras. At this point, the river takes a 'U' turn and starts flowing in a south-easterly direction till it debouches into the plains of Nepal after passing through a narrow gorge in the Shiwalik range of hills. As the river enters the plains, it divides into several channels, the more important of which are the Kauriala and the Girwa. Both these channels rejoin at Bharatpur in the Bahraich district of U.P. The river bed from this point onwards is sandy and its course is liable to abrupt changes. Near Gularia, the river receives Sarju on its right and further downstream the Baberi Sarju on its left. The Sarda or Chauka, the most important tributary of the Ghaghra joins Kauriala at Rampur, Mathura.

After the junction with the Sarda, the river is known as the Ghaghra and flows in a generally south-easterly direction forming earlier the boundary between Bahraich and Gonda districts and later between Barabanki and Gonda districts. During its course through Gonda district, the river inundates a large area on its left by spilling its flood water into the rivers Tirhi etc., which join the river on its left bank. The Tirhi joins the Ghaghra near Nawabganj. About 19 km. below its junction with the Tirhi, the river flows by Ayodhya. It then forms the boundary between Faizabad and Ballia districts and flows in continually shifting channels within a broad sandy bed about 6 km. in width. It then flows in many channels through the districts of Gorakhpur, Deoria, Azamgarh and Ballia with the same broad sandy bed. The country has innumerable, long, narrow lakes which are really old beds of rivers. The course of the Ghaghra is confined to a single channel at Dohrighat where kankar reef appears. The width of the valley varies and is sometimes as much as 16 km. To the east of Dohrighat, the river again splits into two channels; the main channel flows through Barhaj town and about 5 km. west of Barhaj the Rapti river joins it from the left. The little Gandak joins Ghaghra about 3 km. south of Gothini village after which it forms the boundary between Bihar and Uttar Pradesh. The river finally joins the Ganga a few km. downstream of Chapra in Bihar. The total length of the Ghaghra is 1080 km., the lower half of which lies in the State of Uttar Pradesh.

(vii) *The Karamnasa*

The Karamnasa rises near Sarodag on the northern face of the Kaimoor range in the Mirzapur district of U.P. at an elevation of 350 m. It flows in a north-westerly direction through the plains of Mirzapur till Lalitpur village. Entering Varanasi district near Govindpur, the river flows on to join the Ganga near Chanusa. Its important tributaries are the Durgavati and the Chandraprabha. The river is 192 km. long of which 116 km. lie in Uttar Pradesh and the balance 76 km. form the common boundary between Uttar Pradesh and Bihar.

(viii) *The Sone*

The Sone, an important right bank tributary of the Ganga rises at Sonbhadra in the Maikala range of hills in Madhya Pradesh at an elevation of 600 m. It cascades through the mountainous areas of the Vindhya range in its initial reach and then flows in a northerly direction for about 230 km. crosses the Kaimur hills and flows in a north-easterly direction before leaving Madhya Pradesh, about 8 km from the Deoria village. After entering Mirzapur district of Uttar Pradesh it flows in an easterly direction and receives the important tributaries *viz.*, the Rihand and the Kanhar on the right bank and the Ghaghar on its left bank. Leaving the Mirzapur district the Sone enters Palamau district in Bihar where the North Koel joins it on its right bank. The river then takes a north easterly course and enters Rohtas districts, opposite Akbarpur. It then forms the boundary between Patna and Bhojpur districts for some distance and then flowing through Patna district, joins Ganga about 16 km upstream of Danapur in the Patna district. The river has a total length of 784 km of which about 500 km are in Madhya Pradesh, 82 km in Uttar Pradesh and the balance of 202 km. in Bihar.

(ix) *The Pun Pun*

The Pun Pun rises in the Chotanagpur Plateau at an elevation of 300 m in Bihar and joins the Ganga about 25 km to the east of Patna after flowing in a north-westerly direction through Gaya and Patna districts. The river has a number of tributaries draining the Chotanagpur plateau, out all these flow now only during the monsoon. The Pun Pun is 200 km long.

(x) *The Kiul*

The Kiul rises in the Chotanagpur plateau at an elevation of 605 and flows first in an easterly direction close to the southern base of the Girdeshwari hills and later in a northerly direction. It then takes a north-easterly direction up to Lakhisarai and joins the Ganga near Surajgarha in the Monghyr district. It has a number of tributaries of which Harohar is the most important. The total length of the river is 111 km.

(xi) *The Gandak*

The Gandak known as the Kali in Nepal, rises near the Nepal-Tibet border at an altitude of 7620 m to the north-east of Dhaulagiri. After flowing for about 100 km in a south-easterly direction in Nepal and receiving a number of tributaries like the Mayangadi, the Bari and the Trisuli, it debouches into the plains of the Champaran district of Bihar at Trivani. At this point two tributaries the Panchnad and the Sonhad join the river. Thereafter, the river flows in a southerly direction and forms a boundary between Uttar Pradesh & Bihar. Before joining the Ganga near Patna, it flows through Champaran, Sarang and Muzaffarpur districts. The total length of the river is 630 km of which 380 km lie in Nepal and Tibet.

(xii) *The Burhi Gandak*

The Burhi Gandak rises in the Champaran district from the springs of the Someshwar hills at an elevation of 300 m. After flowing for a distance of about 56 km, the river takes a southerly turn where it is joined by the Dubhara and the Tour. From this point, the river takes a south-easterly direction and flows through the Muzaffarpur district for about 32 km. In this reach, the river spills over its banks and a number of spill channels take off and rejoin it later. After flowing through the Darbhanga and Monghyr districts, it joins Ganga opposite to the town of Monghyr. Its total length is 320 km.

(xiii) *Adhwara system of rivers*

The rivers draining the area to the east of Bagmati and up to Kamla are known as the Adhwara system of rivers. The Adhwara system of rivers can be divided into three distinct groups as below:

(i) the Adhwara, Jamuna, Sikao, Banhnad and Khirohi group;

(ii) the Singha, Murka and Rato group; and

(iii) the Dhans, Thomane and Darbhanga Bagmati group.

The significant characteristics of these rivers are steep gradients in the Himalayan region and flatter slopes lower down. This results in the silt load being dropped in the middle reaches and consequent spilling of flood waters from one river to another. These rivers shift their courses often and cause extensive flooding.

(xiv) *The Bagmati*

The Bagmati rises in the Shivpuri range of hills in Nepal at an elevation of 1500 m and flows in a westward direction draining the Kathmandu valley. The river cuts through the Mahabharat range of hills in Nepal and enters India at Rasulpur in Muzaffarpur district During its course through the district, a number of spill channels take off from the Bagmati to rejoin it later. The river itself is unstable. The river ultimately joins the Kosi near Barna village on the border of Darbhanga and Sahasra districts.

(xv) *The Kamala*

The Kamala rises in the Mahabharat range of hills in Nepal at an elevation of 1200 m and flows in a southerly direction. After receiving a number of tributaries, it passes through a gorge above Chauphat and debouches into the Terai area of Nepal at Chisapani. It enters the Indian territory near Jayanagar in Darbhanga district. In the lower reaches, it follows the course of the Balan and, therefore, is known as the Kamala-balan. Flowing in a south-easterly direction, it joins the Kosi on the border of Darbhanga and Sahasra district.

(xvi) *The Kosi*

The Kosi is formed by the confluence of three streams *viz.*, the Sun Kosi, the Arun Kosi and the Tamur Kosi, all taking their origin in the Himalayan region of Nepal and Tibet. The Arun Kosi is the biggest of the three streams and has two of the highest peaks in the world *viz.*, Mt. Everst and Mt. Kanchenjunga in its catchment. After the confluence of the three streams, the Kosi flows through a narrow gorge for about 10 km and debouches into the plains near Chatra in Nepal. About 25 km below the Chatra gorge, the river enters Indian territory at Hanumannagar where a barrage has been constructed across it The Kosi, thereafter, runs in a sandy tract almost in level plains and finds its way southwards into the Ganga through a number of channels a few kilometres upstream of Maniharighat. The Kosi brings considerable amount of fine sand as silt and cuts through the friable banks opening new channels for itself over a period of time. The Kosi is well-known for its tendency to change its course generally in a westward direction. During the course of the last 200 years, the river has shifted westwards for a distance of about 112 km and has laid waste large tracts of agricultural land in the Darbhanga and the Purnea districts by depositing coarse silt.

(xvii) *The Mahananda*

The Mahananda rises in the Mahalidran hills of the Himalayas in Darjeeling district of West Bengal at an elevation of 2100 m. The first 20 km of its course lies in the hills of Darjeeling whereafter it flows in a south-westerly direction forming the boundary between India and Bangladesh in the beginning till it is joined by the Balsan. Lower down, the Machi joins the Mahananda at Deshitoli. After receiving the combined streams of the Ratwa and the Kankai, the Mahananda flows in a southerly direction for about 20 km where it bifurcates into two arms. The left branch flows in a south-easterly direction for about 44 km till it is joined by the combined streams of the Ratwa and the Kankai, and enters West Bengal. It then flows for about 60 km in the State when it is joined by Kalindri near Malda on the right bank and lower down by the Tangan on the left bank. It then flows south forming the boundary between India and Bangladesh for about 6 km and enters Bangladesh to join the Padma (Ganga) at Godagiri. The right branch flows in a southerly direction forming the boundary between the States of Bihar and West Bengal before entering West Bengal and then joins the Bhagirathi (Ganga) upstream of Farakka Barrage.

(xviii) *The Dwarka*

The Dwarka rises in the Birbhum hills at an elevation of 150 m and joins the Bhagirathi in the Murshidabad district of West Bengal. One of its important tributaries is the Mayurakshi river on which a dam has been built for irrigation. It is 134 km in length.

(xix) *The Ajay*

The Ajay rises in the hills of Santhal Parganas and Hazaribagh districts of Bihar.

It flows in a south-easterly direction through the Santhal Parganas district of Bihar and Birbhum and Burdwan districts of West Bengal and falls into the river Bhagirathi near Katwa. Its total length is 276 km.

(xx) *The Damodar*

The Damodar-Rupnarayan system is, perhaps, the most important system to join the Ganga on its right bank east of the Sone. The Damodar drains Ranchi, Hazaribagh, Dhanbad and Santhal Parganas districts of Bihar and the Barkura and Burdwan districts of West Bengal. Rising in the South-east corner of Palamau district of Bihar, it flows in a south easterly direction for about 40 km and then forms the boundary between Hazaribagh and Ranchi districts. It then enters Hazaribagh district and flows in an easterly direction for about 145 km and receives the Bokaro. The river then enters Dhanbad district where it receives an important tributary *viz.*, the Barakar whereafter it enters West Bengal and flows through the Bankura and Burdwan districts. It flows past the town of Burdwan, turns south and joins the Hooghly near Fulta point. The river is 541 km long.

(xxi) *The Rupnarayan*

The Rupnarayan rises in the Tilabni hills in Bihar and flows in a tortous south-easterly course through Bankura district before entering the Burdwan district. The Silai nadi joins Rupnarayan in Midnapur district. After a further course of about 80 km forming the boundary between the districts of Midnapur, Hooghly and Howrah, the river joins the Hooghly near Nurpur immediately downstream of the confluence of the Damodar. The river has a total length of 254 km which is tidal for almost the entire length.

(xxii) *The Haldi*

The Haldi river joins the Hooghly below its confluence with the Rupnarayan. The Kasai, its important tributary, has its origin in Bihar and after leaving that State, it flows through Bankura and Midnapur districts in West Bengal before joining the Haldi. There is a storage project on the Kasai.

2.7. North-west region

The main rivers in this region are the Indus and its tributaries—the Jhelum, the Chenab, the Ravi, and the Beas and the Sutlej—all flowing from the Himalayas. The river Ghaggar has also been included in this region. This region covers the States of Jammu & Kashmir and Punjab and parts of Himachal Pradesh, Haryana and Rajasthan.

(i) *The Indus*

The mighty Indus rises north of Mansarover in Tibet at an elevation of 5182 m. After flowing in a north-westerly direction through Kashmir for about 650 km, it takes a sharp turn south through the Bunji gorge and turns west past Nanga Parbat to enter Pakistan. In Pakistan, it receives the Kabul river from Afghanistan opposite to Attock. The major tributaries in the plains are the Jhelum, the Chenab, the Ravi, the Beas and the Sutlej, the accumulated waters of which are led into it by the Panjnad above Mithankot about 805 km. from the sea. The mountain tributaries of the Indus are the Zaskar, the Dras, the Ashor, the Shyot and the Shigar. The total length of the river is 2880 km of which 1610 km lie in Pakistan.

(ii) *The Jhelum*

The Jhelum rises in Verinag at the upper end of the Kashmir valley and is fed by the everlasting snows of the Lidder valley. Below Srinagar, it receives the Sind before joining the Wullar lake. Below Baramula, the Jhelum leaves the valley and rushes headlong down a deep gorge and then takes a westerly direction up to Muzafarabad where the Kishenganga joins it on the right. Thereafter, the river flows south along the border of Kashmir State entering Pakistan north-east of Jhelum city, about 402 km from its source. After traversing another 322 km, it joins the Chenab at Trimmu.

(iii) *The Chenab*

The Chenab rises in Lahul in Himachal Pradesh and is formed by the two streams, the Chandra and the Bagha. It flows through the Pangi valley of Himachal Pradesh and the submountainous region of South Kashmir up to Akhnoor where it enters Pakistan below the junction of Tawi (on which is situated the town of Jammu). In Pakistan, the Chenab flows over 644 km to Panjnad where it joins the Sutlej, having received the waters of Jhelum and Ravi en route.

(iv) *The Ravi*

The Ravi rises near Kulu, flows westward through a triangle formed by the junction of Pirpanjal and Dhaola Dhar ranges, and debouches into the Punjab plains near Madhopur. After flowing a total distance of 376 km from its source, it enters Pakistan 26 km below Amritsar and near Lahore.

(v) *The Beas*

The Beas rises in the north of Rohtang pass (4062 m above MSL) in Kulu. Fairly steep in its upper portion, it meanders lower down in a westerly course through the hilly country. On meeting the Siwalik hills in Hoshiarpur, the river sweeps sharply northwards then bending round the base of the hills, it takes a southerly direction. It flows through a gorge from Larji to Talwara and enters the Punjab plains to join Sutlej at Harike after a total course of 460 km all in India.

(vi) *The Sutlej*

The Sutlej rises at an altitude of 4630 m near the Darma pass on the Zaskar range and flows through Tibet before entering India. After flowing in a north-westerly direction along the northern slope of the Kailash mountains also, it turns southwards and enters the Punjab plains near Rupar. Thereafter, it flows in a westerly direction up to near Ferozepur where it forms a boundary with Pakistan and enters Pakistan near Suleimanki. It joins Chenab at Panjnad, about 1440 km from its source.

(vii) *The Ghaggar*

The river Ghaggar has its source near Dagshai, a small hill station at an elevation of 1927 m in the Simla District of Himachal Pradesh. The river flows in a generally southwesterly direction practically throughout its length. It enters the State of Haryana near Kalka about 10 km from its source. Continuing to flow in the same dirction the river crosses the boundary line between Punjab and Haryana at a number of places. The Patielwali nala joins it at two different places on its right bank. Then it receives through the Saraswati, the combined waters of its three important left bank tributaries, namely, the Tangri, the Markanda and the Saraswati, near village Shatrana about 148 km from its source. From thereon the direction of flow of the river is more westerly than southerly and it crosses the Bhakra Main line canal and the Ghaggar Branch of the Bhakra system. It continues to flow for about 107 km more in a generally south-westerly direction and then the river is controlled at the Ottu weir for taking off irrigation canals. Thereafter, the river disappears in the sandy hills of the Rajasthan desert. The river has a total length of about 241 km.

2.8. Central India & Deccan region

The important rivers in this region are the west flowing rivers, the Narmada and the Tapi and the east flowing rivers the Subarnarekha, the Baitarni, the Brahmani, the Mahanadi, the Godavari, the Krishna, the Pennar and the Kaveri. This region covers all the southern States viz., Andhra Pradesh, Karnataka, Tamilnadu and Kerala and the States of Orissa, Maharashtra, Gujarat and parts of Madhya Pradesh.

2.8.1. *Narmada*

The Narmada, rises near Amarkantak of the Maikela range in the Shahdol district of Madhya Pradesh and is the largest west flowing river in the peninsula. It flows towards the west through M.P. for about 1079 km. For the next 35 km. it forms the boundary between Madhya Pradesh and Maharashtra and for another 35 km. it forms the boundary between Maharashtra and Gujarat. The lower reach of 159 km is entirely in the State of Gujarat.

The river has a number of drops in the head reaches as well as near Jabalpur (404 km), Mandhar (806 km), Thardi (853 km) and Maheswar (966 km) where the river drops by heights of 15 m, 12 m, 12 m and 6.4 m respectively. Near Jabalpur, it flows through the famous marble rocks from which it merges into the upper plains. Flowing generally westward, it enters the middle plains near Panghat in East Nimar district. After crossing the middle plains, the river enters the lower hilly regions and flows through a 113 km. long gorge formed by the converting of the Vindhyas from the north and the Satpuras from the south towards the river. Emerging from the gorge, the river enters the lower plains in Gujarat and meanders in broad curves subjected to serious floods till it reaches Broach. Below Broach it widens into a broad estuary and falls in the Gulf of Cambay.

The major tributaries of the Narmada are the Burhner and the Banjar in the head reach, the Hiran, the Sher, the Shakkar, the Tawa, the Chhota Tawa, the Barna and the Kundi in the middle reach and the Goi, Uri, Hatni, the Karjan and the Orsang in the lower reach.

2.8.2. *The Tapi*

The Tapi is the second largest west-flowing river of the Peninsula. It rises near Multai in the Betul district of Madhya Pradesh State at an elevation of 752 m in comparatively open country. In the head reach, covering a distance of about 241 km, the river traverses on open and partially cultivated plain before plunging into a rocky gorge in the Satpura hills and emerging below Burhanpur. In the next reach of 290 km, the river flows through the Khandes district of Maharashtra and thereafter receives the Purna, a major tributary from the left and flows through the broad and fertile Khandesh plains. In the next reach of about 80 km, it passes through a wild and almost uninhabited country. Thereafter, there are a series of rapids for a distance of about 32 km, between Kakrapar and Kamalpur resulting in the river falling by 4.6 m. In the last reach of 113 km, the river passes through the Gujarat plains and after flowing past Surat city drains into the Arabian sea. The tidal influence is felt up to 48 km from its mouth in the Gulf of Cambay.

The total length of the river from the head to its outfall into the sea is 724 km of which 228 km are in Madhya Pradesh, 228 km in Maharashtra, 214 km in Gujarat and the remaining 54 km form the common boundary between Madhya Pradesh and Maharashtra. The important tributaries of the Tapi are the Purna, the Vaghur, the Girna, the Bori the Panjhra, the Buray, the Aner, the Arunawati and the Gomai.

2.8.3. *The Subarnarekha*

The Subarnarekha, rises near the Nagri village in the Ranchi district of Bihar at an elevation of about 600 m. Initially it flows in an easterly and north-easterly direction and then turns to the right and flows along the Bihar-West Bengal border for a length of 34 km. Thereafter it enters into Bihar and flows for 144 km. in a south-easterly direction after which it turns and forms the boundary between Orissa and Bihar States for 11 km. It then enters West Bengal and after flowing for 64 km. in easterly and south-easterly direction enters Orissa. It then flows in a south-easterly direction to join the Bay of Bengal. The river 395 km in total length flows for about 269 km in Bihar, 64 km in West Bengal and 62 km in Orissa.

It has three main tributaries, namely, the Kanchi, the Karkari and Kharkai. They all join the main river from the right. The biggest tributary is Kharkai. It rises north of Talbandh village in the Mayurbhanj district and joins subarnarekha near Jamshedpur.

2.8.4. *The Baitarni*

The Baitarni, rises in the hills of Keonjhar district in Orissa at an altitude of 900 m near Mankarnacha village. Initially flowing in a generally northerly and north-easterly direction up to Jaitgarh (80 km) it turns round to flow in a south-easterly direction for a length of 194 km. up to Jajpur. It then changes direction and flows in an easterly direction for the remainder of its course and discharges into the Bay of Bengal near Palymra point. The total length of the river is 355 km and it lies entirely in Orissa. The principal tributaries of the Baitarni are the Salandi and the Mantai. The Salandi joins the Baitarni from the left north-west of Rajkalika. The Mantai also joins from the left near Dhamra.

2.8.5. *Brahmani*

The Brahmani known as the South Koel in the upper reaches rises near Nagri village in the Ranchi district of Bihar at an altitude of 600 m. It flows initially in north-west direction for about 47 km and then turns to the left and flows in generally southerly direction for 217 km up to Manoharpur. In this reach, it receives the Karo, a major left bank tributary and enters Orissa 258 km from its source. Beyond Manoharpur, the river turns to the right and flows in a south-westerly direction for a distance of 55 km up to Rourkela and receives the major right bank tributary, the Sankh. Below this confluence, the river is known as Brahmani and flows in a south-easterly direction for 260 km in the course of which it receives another major tributary, the Tikra. Thereafter, flowing in a generally easterly direction, the Brahmani falls into the Bay of Bengal opposite Wheeler island. The river is also called as Maipura in the tail reach. The total length of the river is 799 km of which 258 km are in Bihar and the balance in Orissa.

2.8.6. *Mahanadi*

The Mahanadi, rises in a pool near Pharaiya village in Raipur district of Madhya Pradesh and flows in a west and north-westerly direction for about 200 km. In this reach, a number of streams join the river. But about 13 km above Sheorinarayan in Bilaspur district it receives its first major tributary, the Seonath. Beyond this confluence after flowing for about 200 km in an easterly direction, the Mahanadi enters Orissa and is joined by the Ib. Little lower down is the Hirakud dam near Sambalpur from where it turns and flows in a southerly direction up to Sonepur where it receives the Ong. Thereafter, the river flows in a south-easterly direction and receives the Tel and comes across the eastern ghats. Between Jamudeli and the Baramul for a distance of 23 km it passes through the Satkosia gorge. At Kantilo it turns east-north-east and near Pathpur it flows through the Kaimundi gorge. Below this gorge, it emerges into the delta at Naraj. Below Naraj, it splits into the Katjuri and the Birupa which branches split and unite. Throwing off numerous branches the Mahanadi ultimately falls into the Bay of Bengal near False point. The total length of the river is 851 km of which 357 km are in Madhya Pradesh and the balance 494 km in Orissa.

2.8.7. *The Godavari*

The Godavari runs across the Deccan from the Western Ghats to the Eastern Ghats for a distance of 1465 km. It rises in the Nasik district of Maharashtra at an altitude of 1067 m and at a distance of 80 km from the Arabian Sea. It flows generally in a south-easterly direction through Maharashtra for about 693 km and then 772 km through Andhra Pradesh and falls into the Bay of Bengal.

In Maharashtra, the Godavari receives the waters of the Darna, Kadava, the combined waters of the Pravara and the Mula and the combined waters of the Purna and Dudna rivers. At the border of Maharashtra and Andhra Pradesh the waters of Manjra join it from the south. At this point, the Godavari flows at an elevation of 329 m. About 306 km below its confluence with Manjra, the river receives the Pranhita which brings the combined waters of the Penganga, the Wardha and the Wainganga which drains Nagpur and the southern slopes of the Satpura range. 48 km. lower down, the Indravati, which drains the erstwhile Bastar district, joins the river. The last major tributary is the Sabari from Orissa which falls into the Godavari 100 km above Rajamundri. Below Rajamundri, the river divides itself into two main streams, the Guatami Godavari on the east and the Vashishta Godavari on the west, which flow down to the sea through a wide alluvial delta formed over the ages by the masses of silt which the river has deposited.

The Godavari is the largest of the Peninsular rivers and for sanctity, picturesqueness and utility, it is surpassed only by the Ganga and the Indus. In fact it is held in reverence as Vridha Ganga (old Ganga) or Dakshin Ganga.

2.8.8. *The Krishna*

The Krishna is a great river of South India which like the Godavari and the Kaveri flows almost across the Peninsula from east to west. It rises in the Western Ghats at an altitude of 1337 m just north of Mahabaleshwar about 64 km from the Arabian sea.

About 137 km from the source, it receives a major tributary, the Koyna from the western side of Mahabaleshwar hills. Lower down it receives the Yerla from the left and then the Varna, the Panchganga and the Dudhganga from the right. Just near its confluence with Dudhganga and about 306 km from its source, the Krishna enters Karnataka State. After flowing for 201 km in Karnataka territory, the Krishna receives from its right, the waters of the Ghataprabha and 35 km lower down, those of the Malaprabha. Both these tributaries have their source in the Western Ghats. A short distance downstream of its confluence with the Malaprabha, the Krishna drops about 122 m from the table-land of the Deccan plateau to the alluvial lands of Raichur. The Krishna receives its two major tributaries, the Bhima and the Tungabhadra, the former on its left at 789 km from its source and the latter 129 km further downstream near Kurnool from its right. Both the Bhima and the Tungabhadra drain large areas of the Westen Ghats and each is a major river in its own right. From a short distance below its confluence with the Tungabhadra, the Krishna flows through a deep gorge, cutting across a series of hills for nearly 290 km before emerging into the coastal belt at Pulichintala. Beyond this point, the river flows for about 80 km before it spreads into the delta. Vijayawada is at the head of the delta. The Dindi and the Musi join the Krishna from its left between Kurnool and Pulichintala and two more tributaries, the Palleru and Muneru also from the left, fall into the river between Pulichintala and Vijayawada. The river falls into the Bay of Bengal through two principal channels.

The total length of the river is about 1400 km of which 360 km are in Maharashtra 483 km in Karnataka and 612 km in Andhra Pradesh.

2.8.9. *The Pennar*

The Pennar is one of the inland rivers of the peninsula flowing to the east and is the next largest to Kaveri. It rises in the Chenna Kesava hill of the Nandi-durg range in Karnataka State. It flows in a north-westerly direction for a distance of 48 km through Kolar and Tumkur districts of Karnataka and enters Andhra Pradesh. Two of its tributaries Kumudavali and Jayamangali join it in its 69th and 82nd kilo metre respectively from its source. After flowing 67 km through Anantpur district in Andhra Pradesh, it re-enters Karnataka and cuts across the Tumkur district for about 13 km to emerge into Anantpur district in Andhra Pradesh. Beyond the confluence of the Jayamangali, the river runs almost northwards for a distance of 146 km passing through the plains studded with tanks. It turns east near Ponnahobalam and flows through the Marutia and Katrimala reserve forest ranges. The Chitravadi, a major tributary falls into the Penner on its right at the 336th km of its run. Beyond this confluence, the Pennar forces its way through the narrow Gandikota gorge in a north-easterly direction for a distance of about 10 km and emerges near the town of Jammalamadugu. Then it takes a sharp turn toward the south-east and flows near Kamalapuram when it receives two major tributaries the Kunderu and the Papagni within 3 km. The river continues to flow in a south-easterly direction, cuts across the Nallamala hill range and passes through the town of Siddhavattam. After receiving the Sagileru it turns eastwards and near Boyanapalli, it is joined by the Cheyyaru flowing from the right. Nineteen km below this confluence, the river emerges from the Velikonda hill range of the eastern ghat through the narrow gorge at Somasila and enters the plains. At the 528th km from its source, the river flows over the Sangam anicut and traversing a further distance of 35 km, crosses the Nellore anicut near Nellore. Thereafter, it flows for another 14 km and falls into the Bay of Bengal. The total length of the river is 597 km of which 61 km are in Karnataka and the balance of 536 km in Andhra Pradesh.

2.8.10. *The Kaveri*

The Kaveri rises at Talakaveri on the Brahmigiri hills of the Western Ghats in the district of Coorg at an elevation of 1341 m. The course of the river through the Coorg district is tumultuous. At the end of this reach, it is joined by the first important tributary, the Harangi. The river has been dammed at about 19 km north-west of Mysore city and two important tributaries, namely, the Hemavathi and the Lakshmanatirtha join the Kaveri into the reservoir. It continues to flow eastwards for 15 km up to Srirangapatnam and then changes its course sourth-eastwards. In the next 25 km, it receives the Kabbni and the Suvarnavathi and takes a north-easterly direction piercing through the Eastern Ghats near Sivasamudram. At Sivasamudram, the river falls by about 97 m in a series of falls and rapids and after flowing through a very narrow gorge, continues its eastward journey and forms the boundary between Karnataka and Tamilnadu States for a distance of about 64 km. Below Sivasamudram, it receives the Simsha and just before entering the Tamilnadu, it receives the Arkavathi.

In Tamilnadu, the Kaveri continues to flow eastwards up to Hoganekal falls and takes a southerly course and enters the Mettur reservoir. The river leaves the Eastern Ghats below Mettur and is joined by Bhavani about 45 km downstream. The river thereafter follows a more easterly course and is joined by the tributaries the Noyil and the Amaravathi before entering the Tiruchirapally district. The river here is wide with a sandy bed in the reach and is known as the 'Akhanda Kaveri'. Immediately below Tiruchirapally, the river splits into two branches which are controlled by the upper anicut. The northern branch called the Coleroon is the main flood carrier and it flows in a north-easterly direction to enter the Bay of Bengal near Porto Novo. The southern branch continues to be called the Kaveri. This branch further divides into the Kaveri and the Vennar below the grand anicut built downstream of the Srirangam island. These channels are utlised as main canal for irrigation in the delta net work of canals. Some branches find their way to the sea and fall into the Bay of Bengal while others are lost in the field . The Kaveri branch falls into the Bay of Bengal at Kavaripatnam, 13 km north of Tranquebar as an insignificant stream.

2.8.11. *Other rivers of the Central India and Deccan*

(a) *West flowing rivers*

We have the desert rivers, the Luni, the Machhu, the Rupen, the Saraswati and the Banas. Thereafter, between the Gulf of Kutch and the Tapi river, other than the Narmada river, there are 4 rivers viz., the Bhadar, the Shetrunji, the Sabarmati and the Mahi. Between the Tapi river and Kanyakumari, there are as many as 115 rivers of which 62 rivers (5 in Gujarat, 11 in Maharashtra, 3 in Goa, 1 in Karnataka, 32 in Kerala and 1 in Tamilnadu) are the more important ones. Fourteen of these are considered important enough to be described here.

(i) *Luni*

The Luni rises south of Pilwa village in the Nagaur district of Rajasthan and flows in a generally south-westerly direction up to the village of Govindgarh whereafter it turns to the right and flows in a north-westerly direction up to the village of Alhiawas. The river then turns to the left and flows in a generally south-westerly diection up to the village Samdari. The important tributaries that join the Luni in this reach are the Mitri, the Litri, the Bandi and the Sukri. Further down the river turns to the right and flows in an almost westerly direction till it reaches the village of Gamesra when it changes its direction and assumes a generally south-westerly course. About 10 km north of Ganda village, it receives its most important tributary the Jawai. The river finally disappears in the great Rann of Kutch. The Luni has a total length of 482 km.

(ii) *The Machhu*

The Machhu rises near Badla in the Rajkot district of Gujarat and flows in a generally northerly direction for total length of 140 km to join the little Rann of Kutch near the village of Mallya.

(iii) *The Rupen*

The Rupen rises east of the village of Kodram in the Mehsana district of Gujarat and flows in a generally south-westerly direction for a total length of 154 km to join the little Rann of Kutch.

(iv) *The Saraswati*

The Saraswati rises north east of the village Jaloter in the Banaskanta district of Gujarat and flows in a generally south-westerly direction for a total length of 144 km to join the little Rann of Kutch.

(v) *The Banas*

The Banas rises east of Sirohi town in the Sirohi district of Rajasthan and flows in a south-easterly direction for a length of 17 km up to the village of Jharoli. Thereafter, it flows a south-westerly direction and receives its major distributary the Sipu and finally drains into the little Rann of Kutch west of the village of Ved.

(vi) *The Bhadar*

The Bhadar rises south east of the village of Amjali in the Rajkot district of Gujarat and flows in a generally south-westerly direction for a total length of 198 km to outfall into the Arabian sea near Navibunder.

(vii) *The Shetrunji*

The Shetrunji rises near the village of Dalakhia in the Amreli district of Gujarat at an elevation of 300 m and flows in a generally north-easterly direction for a length of 48 km and then turns right and flows in a generally easterly direction for about 134 km more and outfalls into the Gulf of Cambay, south east of Talaja.

(viii) *The Sabarmati*

The Sabarmati is another major-flowing river draining into the Gulf of Cambay. It rises in the Aravalli hills in the Rajasthan State at an elevation of 762 m. After flowing for about 48 km in Rajasthan, it enters the Gujarat State and receives the Wakal 3 km downstream near the village of Ghonpankhri. Flowing in a generally south-west direction, it receives the Sei and then the Harnav. Beyond this confluence it flows through the Dharoi gorge. The Hathmati, a major tributary joins the river after it emerges from the gorge and the river continues to flow south-westwards passing Ahmedabad at about 238 km from its source. Another major tributary, the Watrak joins it from the left 65 km downstream of Ahmedabad. The river continues to flow for a further 68 km in a south-westerly direction and outfalls into the Gulf of Cambay in the Arabian sea. The total length of the river is 371 km of which about 48 km are in Rajasthan and the remaining 323 km in Gujarat.

(ix) *The Mahi*

The Mahi is one of the major west flowing rivers running into the Gulf of Cambay, the third in order of size, the first two being the Narmada and the Tapi. The Mahi rises on the northern slopes of the Vindhyas near the village of Sardarpur in the Dhar district of Madhya Pradesh at an elevation of 500 m. It first flows northwards for a length of 70 km through the Dhar and Jharna districts of Madhya Pradesh and is joined in this reach by the Bagori from the left. Turning westwards, the river flows through Ratlam district for a length of 39 km when it is joined from the south by the Pampavati. Turning northwest thereafter, the river flows for another 58 km to enter Rajasthan at Ambapara. In Rajasthan, the Mahi flows in a south-westerly direction for 174 km and is swelled by two important tributaries, the Som from the right and the Anas from the left. 341 km from its source the river enters Gujarat and continues to flow in a south-westerly direction and is joined by the Panam and falls into the Gulf of Cambay. It has a total length of 583 km of which 167 km are in Madhya Pradesh, 174 km in Rajasthan and the remaining 242 km in Gujarat.

(x) *The Purna*

The Purna rises just northwest of Varse in the district of Dhulia of Maharashtra State at an elevation of 500 m. It flows in a generally east west direction for 40 km and then takes a turn towards the north-west. About 14 km lower down, a tributary joins it on its right bank. Flowing in an east-west direction, it receives another tributary near the village Ranvery. Then, taking a sharp bend and flowing westwards, it outfalls into the Gulf of Cambay near Matwad. The total length of the river is 142 km.

(xi) *The Ambika*

The Ambika rises near the village of Jamdar in the Dangs district of Gujarat State at an elevation of 600 m and flows in a generally north-westerly direction for 36 km up to the village of Pimpri. Thereafter it flows in an east-west direction for about 85 km, then makes a circle and flows in a north-south direction till Billimora when it turns to an east-west direction and flows for another 16 km and outfalls into the Gulf of Cambay. The total length of the river is 142 km.

(xii) *Vaitarna*

The Vaitarna rises north of the village of Jaivar in Nasik district of Maharashtra State at an elevation of 800 m and flows for about 20 km in a generally north-south direction with one sharp bend, whereafter it follows a south-west course for about 42 km up to the village of Veda. About 6 km lower down, the Pinjal joins the river. Thereafter the Vaitarna flows for another 19 km in a generally east-west direction up to the village of Gorba where it changes its direction to north-west to flow for about 13 km up to the villarge Manor. Here, the river again takes a sharp bend towards the southwest, for about 10 km where two tributaries join the river. Then the river flows in a north south direction for about 14 km, makes a semi-circle and falls in the Agashi Bay of Arabian sea under the Dahisar Bridge of the Western Railway. The total length of the river is 126 km.

(xiii) *The Ulhas*

The Ulhas rises near the village of Lonauli in the district of Pune in Maharashtra State at an elevation of 600 m. With a small bend near Karjat, the river flows in a south-north direction up to Vangani where it makes an 'S' turn. It then flows for about 24 km till it crosses the Kalyan Bosai road. Five small streams join the river on its right bank up to this reach. The river then follows a serpentine course in the east-west direction till it bifurcates near the Dombivli tunnel. One branch flows to the north and other to the south. Two of its important tributaries, the Bhatsai and Kalu Join near Titwala and their combined waters join the Ulhas just north of Kalyan. The main branch of the river outfalls into the Arabian sea opposite the port of Bassein. The total length of the river is 122 km.

(xiv) *The Savitri*

The Savitri rises to the east of Varandha in the district Kolaba of Maharashtra State at an elevation of 600 m and flows in a generally south-western direction and outfalls into the Arabian sea near the village of Devgarh. The total length of the river is about 80 km.

(xv) *The Mandavi*

The Mandavi is an important river of Goa. It rises about 10 km north east of Sonsagar in Belgaum district of Karnataka at an elevation of about 600 m. One of its branches outfalls into the Rachol near Dabolim. The main river, however, outfalls into Marmagao Bay in the Arabian sea near Panjim, the capital of Goa. The river is 87 km long.

(xvi) *The Kalinadi*

The Kalinadi rises in the village of Bidi in the Belgaum district of Karnataka State at an elevation of about 600 m. Known as the Dogi in its upper reaches it flows in a generally south-east direction for about 56 km towards the village Devikop after which it flows in a generally south-east direction for about 66 km. About 31 km east of the village of Kadra, the river takes a generally east-west direction and outfalls into the Karwar Bay of the Arabian Sea near the town of Karwar. The Pandhri is one of its important tributaries. The total length of the river is 153 km.

(xvii) *The Gangavali*

The Gangavali, known as the Bedti in its upper reaches, rises about 7 km south of the district town of Dharwar in Karnataka State at an elevation of about 700 m and flows in a generally south-east direction for about 12 km up to Hubli whereafter it flows north-south for about 72 km. It then takes a turn towards the south-west, changes its direction to east-west towards the end and falls into the Arabian sea near Gokaran. Its total length is 152 km.

(xviii) *The Sharavati*

The Sharavati has its source at Humacha in Shimoga at an elevation of about 700 m and flows in a generally north-south direction for about 13 km up to Riponpet. Thereafter, it merges into the Linganamakki reservoir and the river flows in a generally north-west direction falling over 275 m at the famous Jog falls. It then flows in an east-west direction to its outfall in the Arabian sea near Honaver. The total length of the river is about 122 km.

(xix) *The Netravati*

The Netravati rises between Kudremukh and Ballalrayan Durga in the South Kanara district of Karnataka at an elevation of about 1000 m and flows in a generally north-south direction for 40 km up to Gohattu where it takes a turn towards the west and flows in a generally east-west direction up to its outfall into the Arabian Sea near Mangalore. The total length of the river is 103 km.

(xx) *The Chaliyar*

The Chaliyar known in the lower reaches as the Beypore is one of the major rivers of Kerala. The main river starts from the Elambalari Hills at an altitude of 2067 m and after receiving the waters of its important tributaries, the Cherupuzha, the Iringipuzha, the Kurumbanpuzha, the Kanhirapuzha, the Punnapuzha, the Karimpuzha, the Vadapurampuzha and the Chaliyarpuzha in a total length of 169 km, falls into the Arabian Sea at Beypore.

(xxi) *The Bharatapuzha*

The Bharatapuzha known as the Ponnani in the lower reaches is the longest of the Kerala rivers. The river rises in the Annamalai hills at an elevation of 610 m and flows through the Pollachi taluq of Tamilnadu and Palghat district of Kerala. Its important tributaries are the Gayathripuzha, the Kannadi, the Korayan and the Thuthapuzha. The river joins the Arabian Sea near Ponnani town. Its total length is 251 km.

(xxii) *The Periyar*

The Periyar 228 km in length is the second longest river in Kerala. It rises at the forest-clad Sivagiri peak 30 km south of Devikulam at an elevation of 2438 m and traverses steep mountainous terrain before it is joined by the Mullaiyar, 16 km downstream. The river then turns west and continues to flow in that direction for about 16 km in a sandy bed. After a winding course of about 13 km, the river reaches Vandiperiyar and passes through a second narrow gorge below which it is joined by the Perumthura. Further down, it is joined by six tributaries after which the important tributary Edamala joins the Periyar. Passing Malayattur and thereafter taking a meandering course, the river reaches Alwaye where it divides itself into two branches. The upper branch joins the Chalakudi river at Punthenvelikara and then expands into a broad sheet of water at Munambham. The other branch taking a southerly course is borken up into a number of small channels which fall into the Vembanad lake at Varapuzha.

(xxiii) *The Pamba*

The Pamba, 177 km in length is the third longest river of Kerala. It is formed by the confluence of the Pamba Aaar, Kaki Aar, Arudhai Aari Kakkad Aar and Kall Aaar. The Pamba Aar rises in the Peermedu Plateau at an elevation of 167 m. The Kaki Aar which forms the major tributary of the Pamba river is a much larger stream at the beginning than the main river. The Pamba river, after receiving the Kaki Aar flows in a westerly direction till it is joined by the Arudhai Aar. At Narayanamuzhi, it turns and follows a south-eastern direction until the Kakkad Aar joins it. Beyond the confluence, the river flows in a southerly direction up to Vadasherrikkara where it is joined by the Kall Aar which has its origin in the Valanjakkatti Malai. At Pandanad the river bifurcates—one branch taking a westerly course. The Manimala joins the Pamba in its Neeretupuram branch. The river thereafter flows northwards and falls into the Vembanad lake through several branches.

2.8.11. (b) *East flowing rivers*

(i) *The Burhabalang*

The Burhabalang rises south of Simhalgarh village in the Mayurbhanj district of Orissa at an elevation of 800 m and flows first in a north-easterly direction and then in a south-easterly direction for a total length of 161 km to fall into the Bay of Bengal.

(ii) *The Rushikalya*

The Rushikalya rises near Dighi village on the eastern slopes of the Eastern Ghats in Phulbani district or Orissa at an elevation of about 1000 m. It flows in a generally south-easterly direction for a total length of 146 km and drains into the Bay of Bengal.

(iii) *The Bahuda*

The Bahuda rises near Ramagiri village in Ganjam district of Orissa at an elevation of 600 m. It flows first in a north-easterly direction and then in a south-easterly direction for a total length of 73 km and falls into the Bay of Bengal.

(iv) *The Vamsadara*

The Vamsadara rises south-west of Belaged village in the Phulbani district of Orissa at an elevation of about 600 m and flows in a generally south-easterly direction for a total length of 221 km and falls into the Bay of Bengal.

(v) *The Nagavalli*

The Nagavalli rises near Gunupur village of Kalahandi district of Orissa at an elevation of 900 m on the eastern slopes of the Eastern Ghats and runs in a south-easterly direction for a total length of 217 km to join the Bay of Bengal.

(vi) *The Sarada*

The Sarada rises near Anantagiri village in Vishakapatnam district of Andhra Pradesh at an elevation of 1200 m and flows in a generally south-east direction for about 104 km and falls into the Bay of Bengal.

(vii) *The Varaha*

The Varaha rises near Lammasingi village of Vishakapatnam district of Andhra Pradesh and runs generally in a south-easterly direction for a total length of 66 km and falls into the Bay of Bengal.

(viii) *The Tandava*

The Tandava rises south west of Chintapalli village in Vishakapatnam district of Andhra Pradesh and flows in a south-easterly direction for a total length of 73 km to join the Bay of Bengal.

(ix) *The Vogarivagu*

The Vogarivagu rises south-west of Nekarikallu village in Guntur district of Andhra Pradesh at an elevation of 150 m and flows in a southerly direction for a total distance of 102 km and falls into the Bay of Bengal.

(x) *The Gundlakamma*

The Gundlakamma rises near Iskagundam village in Kurnool district of Andhra Pradesh at an elevation of 610 m and flows in a north-east, east and southern direction for a total distance of 220 km to join the Bay of Bengal. Its important tributary is the Kandleru.

(xi) *The Musi*

The Musi rises near Gotlagattu village in Nellore district of Andhra Pradesh at an elevation of 200 m and flows in a south-easterly direction for a total length of 112 km and falls into the Bay of Bengal.

(xii) *The Paleru*

The Paleru rises near Gogulapalli village in Nellore district of Andhra Pradesh at an elevation of 325 m and flows in an easterly direction for a total length of 104 km to drain into the Bay of Bengal.

(xiii) *The Maneru*

The Maneru rises north of Sitaramapuram village of Nellore district of Andhra Pradesh on the eastern slopes of the Velikonda range and flows in a generally easterly direction for a total length of 122 km. before its outfall into the Bay of Bengal.

(xiv) *The Kunleru*

The Kunleru rises in the Velikonda range of Eastern Ghats in Andhra Pradesh at an elevation of 150m and flows in a generally eastern direction through the Nellore district for a total length of 93 km and falls into the Bay of Bengal near Mathukuru.

(xv) *The Swarnamukhi*

The Swarnamukhi rises in the Eastern Ghats near Pakala in Andhra Pradesh at an elevation of 300 m and flows up to Chandragiri in a north-easterly direction. Thereafter, it flows eastward for a distance of about 50 km and just before Kalahasti changes its direction northwards to flow for a length of 13 km. Beyond this, it flows in a generally easterly direction and falls into the Bay of Bengal near Durgarajapatnam. The total length of the river is 130 km.

(xvi) *The Arnaiar*

The Arnaiar rises in the eastern slopes of the Eastern Ghats and flows in a generally easterly direction for a total length of about 108 km and falls into the Bay of Bengal near Pullicat in Tamilnadu.

(xvii) *The Kortalayar*

The Kortalayar rises near Kaveripak in the Chingleput district of Tamilnadu and flows in a generally easterly direction for a total length of 108 km through the Chittoor district of Andhra Pradesh and Chingleput district of Tamilnadu to join the Bay of Bengal near Ennore. The river feeds Poondi reservoir and other tanks which are the main source of water supply to the Madras City.

(xviii) *The Cooum*

The Cooum is a small stream which flows through the Chingleput district of Tamilnadu for a total length of 68 km in a generally easterly direction and joins the Bay of Bengal flowing through the Madras City.

(xix) *The Adayar*

The Adayar is a small stream rising in the Chingleput district of Tamilnadu. It flows for a total length of 39 km in a north-easterly and easterly direction to fall into the Bay of Bengal through the Madras City.

(xx) *The Palar*

The Palar rises in the Kolar district of Karnataka State and flows in a generally south-easterly direction for a length of 92 km in the Kolar district of Karnataka to enter the Chittoor district of Andhra Pradesh. After flowing through Andhra Pradesh for a distance of 33 km, it enters the North Arcot district of Tamilnadu. It continues to flow in a generally easterly direction for a length of 202 km in North Arcot and Chingleput districts of Tamilnadu and falls into the Bay of Bengal, north of Kuvattur. The total length of Palar is 343 km.

(xxi) *The Gingee*

The Gingee rises near the village Vettavalam in the North Arcot district of Tamilnadu. It flows in a generally easterly direction for a length of 94 km and falls into the Bay of Bengal near Pondicherry.

(xxii) *The Ponnaiyar*

The Ponnaiyar rises near Hongashenhalli village in the Kolar district of Karnataka State and flows in a generally southern direction through the Kolar and Bangalore districts of Karnataka State for a total distance of 79 km before entering the Salem district of Tamilnadu. The river continues to flow in a generally south-easterly and easterly direction through the Salem district and the South Arcot districts of Tamilnadu and finally flows through the Union Territory of Pondicherry to join the Bay of Bengal just north of Cuddalore. The total length of the Ponnaiyar is 396 km.

(xxiii) *The Vellar*

The Vellar rises at an elevation of 900m near the village of Tumbal in the Chittori Hills of the Eastern Ghats in the Salem district of Tamilnadu and flows in a generally easterly direction through the Salem and South Arcot districts of Tamilnadu for a total length of 193 km before draining itself into the Bay of Bengal near Porto Novo.

(xxiv) *The Vellar of Tiruchi*

Another river known as Vellar rises at an elevation of 400m in the Tiruchirappalli district near Puttanattam village. It flows in a generally eastern direction for a total length of 68 km through the Tiruchirappalli and Thanjavur districts and falls into the Palk Strait near Manamelkudi.

(xxv) *The Varshalei*

The Varshalei rises in Madurai district at an elevation of 450m near Tavarankurichi village. It flows in a generally eastern direction for a total distance of 125 km and falls into the Palk Bay near Sundarapandiyanpattinam.

(xxvi) *The Valgai*

The Vaigai rises on the western slopes of the Varushanad hills at an elevation of 1200m near Kottaimalai in Madurai district and flows in a north and north-easterly direction up to its confluence with the Varahanadi. It then takes a turn towards the east and south east to flow through Madurai and Ramanathapuram districts to join the Palk Bay near Mandapam. The total length of the river is 258 km and it passes through Madurai City.

(xxvii) *The Gundar*

The Gundar rises in the eastern slopes of the Varshanad hills at an elevation of 900m near Saduragiri in Madurai district. It flows in a generally south-easterly direction for a total length of 146 km and falls into the Gulf of Mannar.

(xxviii) *The Vaipar*

The Vaipar rises from the eastern slopes of the Varushanad hill range near Sivagiri in Tirunelveli district and flows in a generally easterly direction for a total length of 130 km to join the Gulf of Mannar near Kalattur.

(xxix) *The Tambraparni*

The Tambraparni rises on the eastern slopes of the Western Ghats at an elevation of 400 m near Alwarkurichi village in Tirunelveli district and flows in a generally eastern direction for a total length of 130 km before outfalling into the Gulf of Mannar.

2.9. Flood prone basins

Almost all the rivers of India carry heavy discharges during the monsoons when their catchments receive intense and heavy rainfall. In the upper reaches, where the rivers flow through mountainous terrain or undulating country, there is generally no overflow of the banks during high discharges and the problem is confined to bank erosion, and, in a few rare cases to shifting of the course due to debris blockade. In the lower reaches, especially where the country is flat, the rivers overflow their banks and cause inundation of low-lying lands often submerging standing crops and property and disrupting communications. In many places inundation is caused by rainfall in the local areas on account of the delay in the drainage of the rain water due to high stages of the river at the outfall. In many estuarine situations, the immediate cause of flooding is the inundation due to the backing up of the stream flow by the rising tide, particularly during the spring tide or by tidal surges.

The problem of floods varies from basin to basin, so also the magnitude of damages caused by floods. The most flood prone areas are in the Brahmaputra basin and the northern sub-basins in the Ganga basin.

2.9.1. *The Brahmaputra Basin*

The basin extends over an area of nearly 580,000 sq. km. and covers large areas in Tibet, India, Bhutan and Bangladesh. In India, the basin covers 81,424 sq. km. of the Union Territory of Arunachal Pradesh, 70,634 sq. km. of Assam, 10,803 sq. km. of Nagaland, 11,667 sq. km. of Meghalaya and 12,585 sq. km. of West Bengal.

The Brahmaputra basin is bounded on the north by the Himalayas, on the east by the Patkai range of hills running along the Assam-Burma border, on the south by the Assam range of hills and on the west by the Ganga basin. The basin has a maximum east to west length of about 1540 km and a maximum north-south width of about 682 km. The basin is of an irregular shape. The upper portion of the basin lying in Tibet mostly comprises mountain ranges and narrow valleys. Similar is the case with the portion of the basin lying in Arunachal and Nagaland. In Assam and Meghalaya, the basin consists of hills, forests, tea gardens and a valley about 80 km wide on the average. In West Bengal also, the basin covers hills, forests and tea gardens of the northern districts besides the fertile plains in the districts of Cooch-Behar and West Dinajpur. In Bangladesh, the basin consists largely of fertile plains and deltaic areas.

The monsoon sets in by the last week of May or in early June, being usually ushered by a depression in the Bay of Bengal. Subsequently, a series of such depressions forming at the head of the Bay and moving inland, gives spells of continuous and moderate to heavy rains generally over the region. The monsoon withdraws in the last week of September or the first week of October. July and August are the rainiest months. Rain is most frequent and heavy on the southern slopes of the Khasi hills on the north-east corner of Assam and in Northern Bengal. Much of the rainfall in June and September is associated with thunder; thundery weather is less frequent in July and August. The rainfall in the Brahmaputra valley ranges from 213 cm in Kamrup to about 414 cm in the Tirap Division of the Arunachal. The Lanka area in Nowgong district on the north of Khasi and Jaintia hills lies in the rain-shadow region and in consequence the annual rainfall there is about 110 cm. The rainfall in the Tista valley varies from 164 cm in West Dinajpur district to 395 cm in Jalpaiguri district. About 85 per cent of the precipitation in the basin is recorded during the monsoon months of May to October. About 12 per cent of the annual rainfall occurs in March and April.

The basin covers fully all the 5 districts of Arunachal Pradesh viz., Kameng, Subansiri, Siang Luhit and Tirap; the Mokokchung district of Nagaland the Lakhimpur, Sibsagar, Darang, Nowgong, Kamrup and Goalpara districts of Assam and Cooch-Behar and Jalpaiguri districts of West Bengal. Parts of Teunsang and Kohima districts of Nagaland, the North Cachar and the Mikir hills districts of Assam, the Garo hills, Khasi and Jaintia districts of Meghalaya, Darjeeling and West Dinajpur districts of West Bengal also lie in the basin. The area under forests is about 12 per cent of the total area of the basin.

The Brahmaputra basin lies in an area of acute seismic activity. The earthquakes of 1897 and 1950 rated as some of the severest, have greatly disturbed the drainage set up of the valley. An analysis of the earthquakes during the period 1920 to 1969 shows that 416 shocks of magnitude 5 and above on Richer scale occurred in north-eastern India. After the earthquake of 1950, there was rise of 3m in the low water levels of Brahmaputra and the Dibang silted up by 6m near Sadiya.

The Brahmaputra used to be navigable up to Dibrugarh and even beyond, a distance of over 1100 km from the sea. Owing to the deterioration of the river channel, however, navigation is now possible only up to Desang-Mukh, 65 km downstream of Dibrugarh. Important inland ports of the Brahmaputra in Assam are Neamati, Tezpur, Gauhati, Pandu and Dhubri. The bulk of traffic which used to be handled by Dibrugarh now moves through Desang-Mukh and Neamati. The Subansiri, the Manas, the Bhorelli, the Dhansiri and the Kopili, tributaries of the Brahmaputra are navigable throughout the year by country boats. The Buri Dihing is navigable by country boats during the rainy season only. With good communications in the plains, abundant rainfall and fertile plains suitable for cultivation for a wide variety of crops, the potential for the development and diversification of agriculture is very great. Still agriculture is unstable mainly because of the occurrence of floods.

Under the influence of the south-west monsoon, the Brahmaputra is subject to severe and recurrent floods. The riverine area in the narrow valleys of Brahmaputra and Barak is very limited with substantial areas covered by hills in the adjoining States|Union territories. This adverse topographical feature coupled with the heavy rainfall ranging from 248 cm in some places in the Brahmaputra valley to 635 cm or more in the north-eastern hills, and largely concentrated during the 4 to 5 monsoon months is responsible for frequent and damaging floods. The total width of the Brahmaputra valley between the foot-hills is only 80 to 90 km of which the river itself covers a width of 6 to 10 km in most places. Forests cover a few km mostly along the foothills. Tea gardens in certain districts occupy much of the high land and the remaining width of the valley occupied by villages and cultivated fields is very narrow.

The abnormal rise of the bed of the Brahmaputra after the 1950 earthquake in the upper Assam region has resulted in spilling of the river on both banks up to the outfall of Subansiri in a length of more than 200 km. In the central reaches, on both banks, a number of spill channels have been thrown up. The uncontrolled discharge and subsequent spilling of these channels cause a serious flood problem in these areas. The lower reaches of the river in Kamrup and Goalpara districts are also subjected to spill. The problem of flooding along the tributaries is due to different reasons. In the upper reaches, the rivers, specially those joining the north bank, create problems by swinging and changing their courses very often. In the middle reach, the rivers spill over their banks during floods in their own basins. In lower reaches, the problem is caused by inadequate drainage capacity of the channels which have to evacuate the rain waters as well as the spills from the tributaries. The Brahmaputra, when in high floods, also backs up into the tributaries and makes them spill creating floods in the lower reaches of the tributaries.

The extreme braided nature of river Brahmaputra coupled with the silt and sand strata of its bank is the main cause of considerable bank erosion in its valley. The excessive sediment load of the Brahmaputra and its tendency for a lateral shift towards south in many stretches appear to be the main reasons of its instability. Studies show that erosion has taken place for a length of 355 km on the south bank and 230 km on the north bank during the period between 1923 to 1954.

Severe erosion is taking place continuously at a number of locations along the Brahmaputra affecting a number of towns, villages and lines of embankments. After the earthquake of 1950, the erosive activity of the river increased. Sadiya town at the confluence of Dabang & Luhit disappeared in 1953. A major portion of Palasbari town disappeared in 1954 and Dibrugarh town was severely eroded and endangered in 1954. Subsequently acute erosion has developed at Kokilamukh, Gauhati, Goalpara, Dhubri, Tarabari, Soalkuchi and numerous other locations, threatening embankments.

The districts of Jalpaiguri and Cooch-Behar and the Silguri sub division of Darjeeling in the northern region of West Bengal suffer frequently from floods in the Himalayan tributaries of the Brahmaputra such as the Tista, the Torsa and the Jaldhaka. These rivers carry large quantities of coarse sediment. They are also subject to flash floods. Whenever floods occur due to the large quantity of sediment being deposited on the river bed in the flatter reaches, the channels are incapable of carrying the flood discharges and in consequence the rivers spill on both banks causing flooding in the area. These rivers sometimes erode their banks and change their courses opening up new channels with considerable damage to the neighbouring areas.

2.9.1. (i) *The Barak Basin*

The Barak basin lies to the south of the Brahmaputra valley. The catchment area up to Badarpur is about 25,000 sq. km. The upper catchment is in Manipur, the valley portion in Assam and the lower portion in Bangladesh. The valley is very narrow and the annual rainfall in the southern slope of the hill range is of the order of 430 cm while in the valley, it is about 290 cm. The valley is low in elevation and the outfall is very congested.

The heavy rainfall averaging 229 cm or more, combined with the main river and 'Chhara' beds aggraded due to silt deposition year after year, causes floods which inundate large tracts of cultivated areas on the margins of rivers. Floods usually affect Silchar and other sub-divisions of Cachar district between Lakhimpur and Karim Ganj.

2.9.2. *The Ganga Basin*

The Ganga basin with a drainage area of nearly 8,61,400 sq. km in India covers slightly more than 1/4th of its total geographical area and is the biggest river basin in the country. Stretching from the Uttarkashi district of U.P. the basin covers practically the whole of Northern India between the Himalayas and the Vindhyas except the State of Jammu and Kashmir. It covers the whole of Uttar Pradesh and the Union Territory of Delhi and parts of Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh, Bihar and West Bengal. Outside India, the basin covers areas in Nepal, Tibet and Bangladesh.

The Ganga basin is bounded on the north by the Himalayas and on the south by the Vindhyas. The ridge between the Indus system and the Ganga system, the great desert of Rajasthan and the Aravalli hills form the boundary on the west. The basin is widest where the main river and its tributaries like the Yamuna and the Chambal originate. The plteau of Central India which projects in the basin restricts its width. This width is the narrowest at the Rajmahal hills in Bihar where the river turns southwards. The Ganga delta begins at this point where the river bifurcates one arm bearing the name of Padma flows into Bangladesh and the other bearing the name of Bhagirathi flows through West Bengal into the sea. The fertility of the Gangetic plains in Uttar Pradesh, Bihar and West Bengal has been mainly due to the fine alluvium deposited by the river.

The principal rainy season for the basin is from June to September. In the plains, rainfall during this season accounts for 80 to 95 per cent of the annual rainfall. In the sub-mountain and mountainous areas, however, south-west monsoon rainfall is only 50 to 60 per cent of the annual. July and August are the rainiest months of the year, together accounting for 55 per cent of the annual rainfall. Rainfall during the season varies from 50 to 250 cm in the mountain and sub-mountain areas and between 40 and 125 cm in the plains. The average rainfall of the whole basin is 97 cm. Flood season in the basin is generally from July to September, during the South-west monsoon. The number of rainy days is 38 in the Yamuna sub-basin, 72 in the Hooghly catchment and 52 for the whole basin.

The Ganga basin is so vast that the physiography, the climate, the soils, the agricultural development and allied characteristics are naturally different in different regions. Therefore, to give an idea of the problem concerned with floods in various regions, the basin has been dealt with under the following sub-basins:—

(i) The Yamuna sub-basin (excluding Chambal)
(ii) The Chambal sub-basin
(iii) The Ramganga sub-basin
(iv) The Gomti sub-basin
(v) The Ghaghara sub-basin
(vi) The Sone sub-basin
(vii) The Gandak sub-basin
(viii) The Burhi Gandak sub-basin
(ix) The Adhwara sub-basin
(x) The Bagmati sub-basin
(xi) The Kamla sub-basin
(xii) The Kosi sub-basin
(xiii) The Mahananda sub-basin
(xiv) The Pun Pun sub-basin
(xv) The Damodar sub-basin
(xvi) The Ajay sub-basin
(xvii) The Dwarka sub-basin
(xviii) The Haldi sub-basin.

(xix) The main Ganga sub-basin

(i) *The Yamuna sub-basin*

The Yamuna basin (excluding the Chambal sub-basin) extends over an area of 2,26,755 sq. km. It covers large areas in the States of Haryana, U. P., Madhya Pradesh and Rajasthan and small areas in Himachal Pradesh and the Union Territory of Delhi. The basin is of irregular shape with the maximum length of 667 km in the north-west—south-east direction and the maximum width of 492 km in the north-east—south-west. The important towns situated on the banks of the river are Delhi, Mathura, Agra, Etawah and Allahabad.

The physiographical and geological features of the upper basin which lies in the Himalayan range account for most of the run-off in the river. This region, on an average, receives a rainfall of 150 cm. The plains receive rainfall varying from 150 cm to 40 cm. Rainfall decreases on the right towards Rajasthan. The entire basin comes under the influence of the south-west monsoon and the major part of the annual rainfall is received between June and

September. Nearly 11.5 per cent of the total areas of the basin is under forests.

The flood problem in the basin is not as severe as that on some of the other tributaries of the Ganga. However, flood spills submerge areas in Haryana and Uttar Pradesh. The districts affected in Uttar Pradesh are Saharanpur, Muzaffarnagar, Meerut, Bulandshahar in the upper reaches and Banda and Allahabad in the lower reaches. Delhi, which lies on the banks of the Yamuna, has been protected against spills of the river by embankments.

(i) (a) *The Sahibi Basin*

The basin covers parts of the States of Rajasthan and Haryana. The total catchment area up to Dhansa is 6,889 Sq. km of which 4,515 sq. km lie in Rajashthan. The river used to disappear in the sand-dunes in Haryana below Rewari during years of low rainfall. Of late, a significant volume of the flood discharge enters Delhi Territory through Najafgarh drain which outfalls in the river Yamuna. The basin is mainly plain country covered with sandy soil. The average rainfall is 49 cm.

The problem of floods in the basin is mainly due to changing course of the river.

(ii) *The Chambal basin*

The Chambal basin extends over an area of 1,39,468 sq. km. The basin is roughly rectangular in shape with an exit passage and has a maximum length of 560 km, in the north-east—south-west direction and the maximum width of 430 km in the north-west—south-east direction. The basin receives rainfall from the south-west monsoons extending from June to September. The maximum annual precipitation in the basin is about 127 cm and the minimum is 36 cm. The area under forests in the basin is about 8 per cent of the total area. The basin does not experience any flood problem.

(iii) *The Ramganga basin*

The Ramganga basin extends over an area of 32,493 sq. km. It is petal shaped with the maximum length of 325 km. in the north-west—south-east direction and maximum width of 160 km in the north-east—south-west direction.

The basin receives most of its rainfall during south-west monsoon season from June to September. The northern districts near the hills receive comparatively more rain than the districts in the plains. The area under forests in the basin is about 21 per cent.

The Ramganga has, a shifting and uncertain course in the plains. During floods, the river overflows its banks opening out new channels and destroys the fertility of the land by depositing coarse sand on it. The extent of the area flooded is, however, not large except near its confluence with the Ganga. The districts affected are Bijnor, Moradabad, Bareilly, Raropur Badaun, Shahjahanpur, Hardoi and Farukhabad.

(iv) *The Gomti basin*

The basin covers an area of 30433 sq. km. and lies entirely in the State of Uttar Pradesh. It is roughly rectangular in shape. The basin is a part of the land formation, filled up and formed by the detritus washed down by the rivers originating from the Himalayan ranges. Only about 145 sq. km. of the total catchment of 30433 sq. km. forms forest land. The basin is flat with a gradual slope from north-west to south-east. The important towns situated on the banks of the river Gomti are Lucknow, Sultanpur and Jaunpur.

Since the Gomti and its major tributaries originate in plains, they carry mainly fine silt. Due to the flat slopes of the river, the sediment load gets deposited in the bed and thus causes the river channel to meander.

The main problem of flooding in the sub-basin is that of inundation due to sluggish bad slope in the river, inadequate waterway in the bridges, shallow and tight cross sections of the river and poor outfall conditions.

(v) *The Ghaghra basin*

The basin has a total catchment 1,27,950 sq. km. of which the area lying in India is 57,647 km. the rest being in Nepal. The country here has innumerable narrow lakes which are really old beds of rivers. In the Bihar State, the tributaries joining the river have silted courses. There are also some low-lying lands called 'chaurs' which remain submerged for considerable period due to drainage congestion. The river brings large quantity of silt during the floods and deposits the same in its bed due to the poor bed slope and this results in the tendency to meander and consequent inundation of vast areas. Flooding is generally caused due to spilling over banks. The entire area on the right of the Ghaghra in the Azamgarh and Ballia districts is liable to inundation from floods.

(vi) *The Sone basin*

The basin extends over an area of 71,259 km. and covers large areas in the States of Madhya Pradesh, Bihar and Uttar Pradesh. The basin is roughly rectangular in shape and has a maximum length of 460 km in the east-west direction and a maximum width of 220 km. in the north-south direction.

The rainfall in the basin varies from 162 cm. in the Vindhyan plateau to about 997 cm. in the plains where the Sone joins the Ganga. Except in the lower most reaches where the river emerges into the Gangetic plain in the Shahabad district, the river flows in hilly and well forested areas. Nearly 40.5 per cent of the catchment is under forests.

The problem of floods in the basin rises only in the lower reaches of the river after it merges out of the hilly reaches into the plains and it is due to spilling over the banks and causing inundation of adjoining areas. The problem is experienced in the low-lying plains between Arrah and Maner.

(vii) *The Gandak basin*

The total cathment area of the basin up to its outfall into the Ganga is 46,300 sq. km. of which 7,620 sq. km. lie in India, the balance lying in Nepal. The basin is roughly trapezoidal in shape up to Valmiki Nagar. It gets most of its rainfall during the south-west monsoon that is from June to October. The annual rainfall in the whole of the catchment varies from 203 cm. to 102 cm. The river has very steep slope in the mountains but after it debouches into the plains, the slope gradually becomes flatter. Like other rivers of North Bihar rising in the Himalayan ranges, it brings enormous quantities of water and silt during the monsoons. The silt load carried gets dropped as the river flows through plains, resulting in a tendency to spill its banks and to shift its course. The river is flowing more or less on a ridge and so any breach in the banks causes great devastation.

The problem of flooding gets accentuated when the Ganga is also in flood and the water of Gandak is prevented from entering into it and gets the backed up waters of the Ganga. The river has been embanked more or less completely and the problem is one of proper maintenance of these banks.

(viii) *The Burhi Gandak basin*

The catchment of the Burhi Gandak is approximately 12,500 sq. km. out of which the hilly area is only 2,130 sq. km. On this account, the river is known for its clear water as the silt content carried by it is not much as compared to the other river systems of North-Bihar. The catchment is fan shaped up to the confluence of the Dhanauti and elongated, narrow, rectangular shaped thereafter.

The normal annual rainfall in the basin is 131 cm. The basin gets about 83 per cent of its total annual rainfall during the period from 15th June to 15th October. The bed slope of the river is steep in the upper region and flat in the plains lower down.

Important towns on the banks of the river are Muzaffarpur, Samastipur and Khagaria. The flood problem which used to be very serious at one time has been more or less controlled except in its lower reaches (Rosera and Khagaria) by the construction of embankments.

(ix) *The Adhwara basin*

The vast tract of most fertile land in North Bihar lying between the rivers Bagmati and Kamla is known as Adhwara basin. It comprises north-eastern part of Muzaffarpur and north-western part of Darbhanga districts. The total catchment area of the Adhwara group of rivers is approximately 4,960 sq. km. of which 2,360 sq. km. like in Nepal. The basin is a plain area built by alluvial soil which is very fertile.

The monsoon breaks in the basin in the second or third week of June and lasts till October. The average annual rainfall in the districts of Muzaffarpur and Darbhanga is about 118 and 125 cm. respectively.

The main cause of flooding in the Andhwara basin is inadequate capacity of the river to accommodate flood discharge. Due to the steep gradient of the rivers, not much flooding is caused in Nepal territory. However, in Indian territory, the gradient being very flat, various tributaries combine their flow through a single channel having inadequate capacity resulting in widespread inundation. Besides, the fine material brought by the rivers in the lower reaches gets deposited near banks which become consolidated and inerodable. This prevents the rivers to increase their sectional capacity.

(x) *The Bagmati basin*

The total catchment area of the basin is approximately 13400 sq. km. out of which 3,749 sq. km. lie in Nepal.

The river spills on both sides in its middle and lower reaches from Dheng to Muzaffarpur—Darbhanga road crossing as bankful capacity of the rives is not more than 560 cumecs against flood discharge of 2,832 cumecs. In this reach the river is in an aggrading stage and has a tendency to meander and change its course.

(xi) *The Kamla-Balan basin*

The river originates in the Kamla Khonch range of hills in Nepal and debouches into the Terai region of Nepal through a gorge near Chisapani and crosses Indo-Nepal border above Jaynagar.

The Kamla-Balan carries heavy sediment load as a result of which it has been constantly meandering. Its abandoned and semi-living courses are all over the district of Darbhanga.

The flood gradient of the Kamla from Chisapani to Jaynagar is quite steep. Thereafter, it is flatter. Due to this flattening of slope and heavy sediment load which the river carries below Jaynagar, it has been changing its course frequently.

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Due to construction of embankments from Jaynagar to Darjia, the river spills are confined within the embankments. However, above Jaynagar, the spills fall into old Kamla channels.

(xii) *The Kosi basin*

The total area of the catchment up to Barahkhetra is about 59,047 sq. km. of which nearly 5,957 sq. km. is under permanent glaciers and snow.

The main monsoon season of the basin extends from June to October during which period about 80 per cent of the annual precipitation occurs. The annual rainfall in the basin progressively increases from about 120 cm. at the foot hills to more than 350 cm. on the southern slopes of the Himalayan range.

The Kosi carries enormous amount of silt load. This varies from year to year and month to month depending on the flow of the river and is highest during the months of June to September.

With the construction of flood embankments, the activity of building delta by the river has been stopped, giving relief to vast areas affected earlier. However, there is still the problem of floods in the lower reaches from where the combined Kamla, Kosi and Bagmati flow. There is enormous drainage congestion in the protected areas as well as in the lower reaches from where the combined Kamla, Kosi and Bagmati flows. There is enormous drainage congestion in the protected areas as well as in the lower reaches where the embankments have not been constructed . The areas between the embankmnts, where even now, a large population resides, is subject to perpetual flooding. There is also the problem of evasion of the earthen embankments on account of the swinging nature of the river.

(xiii) *The Mahananda basin*

The total catchment area of the river Mahananda up to its confluence with the Ganga is about 25,000 sq. km. out of which about 6,000 sq. km. lies in Bihar. The rainfall in the upper catchment of the basin is very high being 559 cm. per annum. In the district of Malda (West Bengal), it is much less viz., 155 cm. per annum. It is only rainfed and so practically dries up during summer.

The bed slope of the river in the upper portion varies from 10.6 metres per km. in the upper-most reach to about 4.8 metres per km. in the plains of Darjeeling district. The slope near the outfall is about 0.0985 metres per km.

The Mahananda spills in almost its entire reach in Bihar. The basin experiences floods almost every year. In its lower reaches in the Malda district, drainage congestion occurs when the level in the Ganga remains high.

(xiv) *The Punpun basin*

The Punpun has a drainage area of 8,530 sq. km. The catchment is elongated. About 85 per cent of the total rainfall occurs during the monsoon months from June to September. Average annual rainfall varies from 99 cm. near its confluence with the Ganga to 134 cm. in upper-most reaches.

Due to low banks and inadequate channel capacities, all the channels in the lower reaches spill heavily over their banks even during normal floods. Thus, almost every year, a vast tract of land is inundated in the lower most reaches. High stages of the Ganga retard the flow and increase the duration of flooding. When in floods, it used to threaten Patna.

(xv) *The Damodar basin*

The basin extends over an area of about 25820 sq. km. of which 18,026 sq. km. pertain to the upper Damodar just above its confluence with the Barakar river The catchment is irregular in shape and somewhat elongated in the lower reach. In the upper reach the topography is hilly while in the lower reach it is flat. The river slope is 1.86 metres per km. for the first 241 km. 0.57 metre per km. in the next 161 km. and 0.16 metres per km. in the last reach.

The average rainfall in the catchment is about 130 cm. The basin covers an important coalbelt and an industrial area. After the construction of the dams under the DVC projects, the floods in the river have been moderated and there is little damage in the Bankura and Burdwan districts. However, flooding takes place on the right bank lower down as it is not protected by embankments in its entire length. The lower trans-Damodar area is also seriously affected. Here, silting in the rivers has reduced the carrying capacity to a small fraction of the maximum flood discharge. So, even minor floods cause spills which find entry into the lower areas of Arambagh, Pursura and Khanakal in the district of Hooghly. The areas being low, drainage congestion persists for a long period once these are flooded during the flood season. The high tides of river Hooghly also affect the drainage of the Damodar river and cause drainage congestion in the lower basin.

(xvi) *The Ajay basin*

The basin extends over an area of about 6050 sq. km. of which about 2797 sq. km. falling in Bihar is hilly while the remaining area is in plains, mostly in West Bengal. The shape of the catchment is rather long and narrow.

The average rainfall in Burdwan district in which the lower reach of the Ajay falls is about 127 cm. In the upper reach of the river, that is in Santhal Pargana district, the annual rainfall is less.

The flood slope of the river in Bihar portion is comparatively steep and there is no spilling in that area. The spilling starts on the right bank of Ajay near its confluence with Hinglow a few miles downstream of Pandabeswar. In the lower reaches the capacity of the river channels is greatly reduced due to silting.

(xvii) *The Dwarka basin*

The area of the basin up to its outfall into the Bhagirathi is about 8,850 sq. km. The upper portion of the basin is barren, eroded and hilly, in the middle, it is alluvial tract and finally, at the outfall it is deltaic region, a part of which is under tidal influence.

The average annual rainfall of the catchment above Ambica Nagar is 141 cm. The slope of the river is very steep in the upper reaches. In the initial reach, the bed slope is about 7.6 metres per km. near about Midnapore the slope is 0.7 metres per km. and near the outfall it is about 0.05 metres per km

The flood problem in the basin is caused due to breaches in old embankments as well as drainage congestion in the lower reach due to synchronisation of high tides in the tidal areas

(xviii) *The Haldi basin*

The basin extends over an area of about 10,210 sq. km. of which nearly 2,072 sq. km. lie in Bihar while the balance is in West Bengal. The basin is narrow and elongated.

The average annual rainfall in the catchment varies between 127 cm. and 147 cm.

The problem of floods in the basin is mainly caused by reduction in the drainage capacity of the channels, inadequate waterways of some of the railway bridges over the river system and adverse effect of the Bhagirathi on the drainage when the Bhagirathi itself is in floods

(xix) *The main Ganga basin*

The main Ganga basin, excluding the sub-basin covers an area of 1,07,331 sq. km. of which 71,302 sq. km. is in Uttar Pradesh, 9,182 sq. km. in Bihar and 26,847 sq. km. in West Bengal. The Ganga rising in the northern district of Uttar Pradesh flows from west to east practically through northern India. The rainfall through varying from region to region, is dominated by the south-west monsoon from June to September. As we advance towards the east, the period of the monsoon is extended over 6 months in a year that is from May to October. In Uttar Pradesh, Dehra Dun district gets the highest rainfall (214 cm). Allahabad district receives the lowest (66 cm). The rainfall in Bihar is not so pronounced as in Uttar Pradesh. The Santhal Parganas district receives the highest rainfall (138 cm.), while the lowest rainfall is in the Monghyr district (95 cm.) In West Bengal, the Howrah district gets the highest precipitation (163 cm.) while Nadia district gets the lowest (131 cm). The upper part of the basin up to Hardwar and some area in the Varanasi district are hilly. The rest of the area lies in the plains. In fact, 18.4 per cent of the total area is under forests and nearly 64.7 per cent of the total area is cultivable. Of the cultivable area, nearly 86.3 per cent is cultivated annually and of the cultivated area, 27.8 per cent is provided with irrigation facilities. Under the irrigated conditions, paddy is the most important crop in Bihar and West Bengal while wheat and barley are the important crops in Uttar Pradesh.

The flood season in the basin is generally from July to September during the south-west monsoon. As the basin is very large in size, natural flood moderation takes place to some extent. However, due to localised heavy to very heavy storms, the drainage channels in many of the sub-basin are unable to carry the storm waters quickly, causing inundation in parts of the basin varying from three to five weeks. Floods in the lower reaches of the river, say below Patna are sustained. During 1971 it was observed that the river was in floods above the warning stage below Patna for about 8 weeks. When the Ganga is in spate, a storm in the catchment of any of its tributaries would create drainage congestion leading to flooding. It is fortunate that whenever there is very heavy rainfall in the Nepal hills and the north bank tributaries of the Ganga are in spate, there is little rainfall in north-west Uttar Pradesh and Madhya Pradesh. So, there is very little contribution from the right bank tributaries *viz.*, the Yamuna and the Sone. Again, the Yamuna drains practically one-third of the total Ganga basin but its contribution is only about 20 per cent of the total average run off. However, the three north bank tributaries Ghagara, Gandak and Kosi having only about 24 per cent of the total catchment contribute about 44 per cent of the total average annual run off of the Ganga basin. Thus, due to lower run off from the basin, the problem of floods in the Yamuna in its lower reach is not so acute. Similarly, the problem of floods up to Ballia on the main Ganga is not so serious except in the two drainage depressions of the Gomti and the Sai in Uttar Pradesh. The main problem of flooding along the main Ganga is confined to areas below the confluence of Yamuna and Ganga at Allahabad. Below Allahabad, the river causes considerable damage due to spills during high floods. The river also erodes banks near Badrinath, Varanasi, Ballia, Mirzapur etc. The Uttar Pradesh Government has constructed the Ballia-Baria Bund on the left bank of the Ganga near the Ballia town to protect land from floods. In Bihar, the Ganga has been embanked between Buxur and Koelwar and near Patna, Chapra and Sonepur. However, when the river is at a high stage the discharge from the tributaries gets backed up and causes widespread damage in the sub-basins and also at their confluence points with the Ganga. The condition is worsened when the floods in the Ganga and its tributaries synchronise.

In West Bengal, the Bhagirathi—Hooghly, which is the name of the Ganga in West Bengal, was the main course of the Ganga until 400 years ago. Now the Bhagirathi functions only as a spill channel and the main Ganga flows along the Padma in Bangladesh. With the reduction of the discharge in the Bhagirathi, the channel capacity in that river has been deteriorating from year to year, thus affecting the navigability of the river and the functioning of the Calcutta Port. Due to reduced upland water supplies, the sea tides in its lower reach penetrate far up the river and bring in large quantities of silt which lead to rise in the bed level of the river. The reduction of the upland supplies has also affected the natural flushing of the rivers in West Bengal and this has increased drainage congestion in many of the off-shoots of the river. In addition to the flood and drainage problem, bank erosion on the right bank of the Ganga below Farakka Barrage up to Lalgola in the Murshidabad district as well as on the left bank thereof up-stream of Farakka barrage also deserves special mention.

2.9.3. *The Indus basin*

The basin extends over an area of about 1,165,500 sq. km. and covers areas in Tibet, India, Afghanistan and Pakistan. The catchment area of the Indus in India is 321,289 sq. km. It extends over the States of Jammu & Kashmir, Himachal Pradesh Punjab and parts of Haryana and Rajasthan besides the Union Territory of Chandigarh. The basin has a double fan or palm shape. The basin in Indian territory has a maximum east-west length of about 855 km and north-south width of about 560 km. The upper portion of the basin lying in Tibet, Jammu and Kashmir, Himachal Pradesh and part of Pakistan comprises mostly mountain ranges and narrow valleys. In Punjab, Haryana and Rajasthan in India and West Punjab and Sind in Pakistan, the basin is one flat vast stretch of what was once desert and waste land, but which is now the renowned and fertile granary of both countries.

The south-west monsoon brings rains in the summer months while the winter rains are caused by the storms in Jammu and Kashmir, which advance from Iran and Baluchistan. The annual rainfall in the plains of Punjab varies between 40 and 80 cm. while in the submontane districts, it is higher, and varies between 80 and 115 cm. In Rajasthan, parts of the Ganganagar and Bikaner districts receive hardly 19 and 23 cm. In Haryana the maximum rainfall of about 216 cm. occurs in the foothills. In Himachal Pradesh the rainfall varies from about 85 cm in the Kinnaur district to 180 cm in the Sirmur district. However, there are places in the Kangra district like Dharamsala and Palampur where the normal annual rainfall is as high as 320 cm and 268 cm respectively. 80 to 90 per cent of the rainfall in the above States takes place during the months from July to September. Nearly 21.7 per cent of the flood reporting area of the basin is covered by forests.

In the Jammu and Kashmir State, the rainfall pattern is somewhat different. The normal annual rainfall in the State varies from 190 cm in Gulabgarh to 9 cm in Leh (Ladakh). The south-west monsoon is the main source of precipitation in Jammu and Kashmir and Kishtwar while winter precipitation is more important in Ladakh, Gilgit and the higher ranges. Unlike many other rivers of the world, the Indus and its tributaries receive practically all their water in the upper hilly part of their catchments. Accordingly their flow is maximum when they emerge from the foothills. There is little surface flow that is added from the relatively large but arid part of the catchment in the plains.

The problem of floods in the basin is caused by Jhelum, a left bank tributary of the Indus in the State of Jammu and Kashmir. When in spate, the river overflows its banks inundating the cultivated lands particularly on left bank between Srinagar and Sangam and on both banks below Srinagar up to Banyari. The main reason for the flooding is the inadequate outflow capacity of the river below the Wular lake.

In Punjab, many small hill torrents and 'choes' spill into the plains during the rainy season. The problem is aggravated by the sudden change in gradient as the rivers emerge from the steeply sloping mountain valleys into gently sloping plains. In the Ganganagar district of Rajasthan, flood damage occurs due to increase in the intensity and duration of flow of the Ghaggar river from its catchment area in Punjab and Haryana.

2.9.4. *River basins of Central India and Deccan*

(i) *The Narmada basin*

The basin extends over an area of 98,796 sq.km. and lies in the northern extremity of the Deccan plateau. It covers large areas in the States of Madhya Pradesh and Gujarat and comparatively smaller area in Maharashtra. The basin has an elongated shape with a maximum length of 953 km from east to west and the maximum width to 234 km from north to south. The basin has five well-defined physiographic regions. They are (i) the upper hilly areas covering the districts of Shahdol, Mandla, Durg, Balaghat and Seoni (ii) The upper plains covering the districts of Jabalpur, Narsimhapur, Sagar Damoh, Chhindwara, Hoshangabad, Betul, Raisen and Sehore, (iii) the middle plains covering districts of East Nimar, part of West Nimar, Dewas, Indore and Dhar (iv) the lower hilly areas covering part of West Nimar, Jhabua, Dhulia and part of Baroda and (v) the lower plains covering mainly the districts of Broach and parts of Baroda. The hilly regions are well forested. The upper middle and lower plains are broad and fertile areas well suited for cultivation.

The normal annual rainfall of the basin is 118 cm. Nearly 90 per cent of this rainfall is received during the 5 monsoon months from June to October. About 60 per cent is received in the 2 months of July and August. The forests cover about 32 per cent of the catchment area.

There is no serious problem of floods in the Madhya Pradesh State. In the Gujarat plains, serious floods occur once in 5 to 6 years causing damage to the city of Broach and other areas. The area affected is mostly on the left bank. The problem gets aggravated if the high flood synchronises with a high tide from the sea.

(ii) *The Tapi basin*

The basin extends over an area of 65,145, sq. km. and is situated in the northern part of the Deccan plateau. It covers large areas in the States of Madhya Pradesh, Maharashtra and Gujarat. The basin has an elongated shape with a maximum length of 587 km from east to west and the maximum width of 210 km from north to south. It has two well-defined physical regions viz., the hilly region and the plains. The hilly region covers the Satpuras and Satmalas, the Ajanta and the Gawilgarh hills and is well-forested. The Khandesh and the Gujarat plains are broad and fertile areas.

The normal annual rainfall in the basin (up to Kathore) is 83 cm about 90 per cent of which is received during the monsoon months from June to October. The forests cover about 25 per cent of the area in the basin.

The problem of floods in the basin is confined mostly in the lower reaches of the river, including Surat city. After the construction of the Ukai Multipurpose project, there has been some relief in the problem of floods.

(iii) *The Subarnarekha basin*

The Subarnarekha basin extends over an area of 18,252 sq. km in the States of Bihar, Orissa and West Bengal. The basin is somewhat fan shaped in the upper reach and elongated in the lower reach. The average rainfall in the basin is 137 cm. About 21 per cent of the basin area is covered by forests.

Widespread inundation is caused by the river in the lower reach owing to inadequate capacity of its natural section to carry the flood discharge. The condition gets worse when heavy rainfall occurs simultaneously with high tides. The flooding is confined mostly to the Orissa and West Bengal delta areas.

(iv) *The Brahmani and Baitarni basin*

The Brahmani and Baitarni basin extends over an area of 51,822 sq. km. in the north-east of the Deccan plateau. It covers large areas in the States of Orissa and Bihar and a small area in M.P. The Branmani sub basin covering 39,033 sq. km. has a long sausage shape. The Baitarni sub basin covering 12,789 sq. km is roughly circular in shape.

The basin has four well defined physical regions (i) the northern plateau, (ii) the Eastern Ghats, (iii) the Coastal plains and (iv) the erosional plains of the central table-land.

The northern plateau and the eastern Ghats are well forested hilly regions. The Coastal plain stretching over the districts of Cuttack and Balasore covers the delta formed by the two rivers and is a fertile area. The erosional plains of the central table land are traversed by the rivers Brahmani, the Baitarni and their tributaries.

The south-west monsoon sets in by the middle of June over the basin and continues to be active till the first week of October. During this period, the basin receives over 90 per cent of its total annual rainfall. The area under forests in the basin is roughly 23 per cent.

The flood problem in the basin is mainly confined to the lower reaches of the two rivers. Since the Mahanadi, the Brahmani and the Baitarni have their channels interconnected in their deltas, the worst floods in the delta occur when there is heavy rainfall simultaneously in the catchment of more than one of the rivers. The spill from one river flows into the other and there is intermingling of water leading to the flooding of most of the areas.

(v) *The Mahanadi basin*

The basin extends over an area of 1,41,589 sq. km in the north east of the Deccan plateau and covers large areas in the States of M.P. and Orissa and only small areas in Bihar and Maharashtra. The upper basin is a saucer shaped depression known as the Chhatisgarh. The basin is circular in shape with a diameter of about 400 km and exit passage of about 160 km length and 60 km breadth.

There are four well defined physical regions in the basin, namely, (i) the Northern plateau, (ii) the Eastern Ghats, (iii) the Coastal Plain and (iv) the erosional plains of the Central table land.

The Northern plateau and the Eastern Ghats are well forested hilly regions. The Coastal plain stretching over the districts of Cuttack and Puri covers the large delta formed by the Mahanadi and is a fertile area well suited for intensive cultivation. The erosional plains of the central table land are traversed by the Mahanadi and its tributaries.

The average annual rainfall in the basin is 144 cm out of which as much as 131 cm falls during the monsoon period. Except in Chhatisgarh coastal plains, the basin has an extensive area under the forests. This is mainly due to the hilly nature of the terrain and lack of transport facilities. The area under forests is roughly 32 per cent of the catchment area.

The problem of floods in the basin is mainly confined to the lower reach of the river in Orissa. The main rivers of Orissa. *viz.,* the Mahanadi, the Brahmani and the Baitarni are inter-connected in the delta and the worst floods occur when there is heavy down pour simultaneously in the catchment areas of more than one of these rivers. The spill from one river flows into the other leading to flooding of most of the delta area. In the course of delta formation the river beds rise gradually and become higher than the adjoining lands. Whenever the rivers are in flood and the water level rises, the drainage of the area gets affected. These conditions have resulted in the formation of small lagoons and swamps in the doabs towards the sea coast.

(vi) *The Godavari basin*

The basin extends over an area of 312,812 sq. km which is nearly 10 per cent of the total geographical area of the country. Lying in the Deccan plateau, it covers large areas in the States of Andhra Pradesh, Madhya Pradesh and Maharashtra, in addition to smaller areas in Karnataka and Orissa. The basin is roughly triangular in shape and the main river itself runs practically along the base of the triangle.

Except for the hills forming the watershed around the basin, entire drainage area comprises rolling and undulating country—series of ridges and valleys interspersed with low hilly ranges. Large flat areas of the type characteristic of the Indo-Gangetic plains are scarce except in delta. The interior of the basin is a plateau, the greater part of which is at an elevation of 300 to 600 m. the general slope is eastwards. Great undulating plains divided from each other by flat topped ranges of hills are the main charcteristics of this plateau. The hill sides are marked by conspicuous wide terraces except in the southern part where the hills are frequently crowned with great 'tors' or rounded hummocks of bare rock the result of constant wealthering. The delta of the Godavari formed by deposits at the mouth of the river over past ages, consists of a wide belt of river-borne alluvium. The process of silt deposition at the mouth of the river is still continuing and the delta is gradually extending into the sea.

The south-west monsoon sets in by mid June and ends by mid October. During this period, the basin receives about 88 per cent of its total annual rainfall. Annual average rainfall in the basin is 113 cm. The forests occupy an area of about 30 per cent of ths catchment.

During the monsoon, the river spills its banks in the lower reaches causing floods particularly in the delta areas. In Maharashtra, the problem is confined to the Nanded town situated on the banks of the river as also to the agricultural lands on the banks of the river in Nanded and Parbhani districts and those on the banks of the Wardha and the Wainganga in the Vidharbha region.

The parts of the basin lying in Madhya Pradesh and Karnataka have generally no serious flood problem. In Orissa, the Indravati and the Sabri sometimes cause flooding. In Andhra Pradesh, the submergence of large areas by the flooding of the Kolleru lake is an acute problem. The flooding of deltaic areas has been prevented by construction of embankments.

(vii) *The Krishna basin*

The basin extends over an area of 258,948 sq. km. which is nearly 8 per cent of the total geographical area of the country and lies in the central region of the Deccan plateau. It covers large areas in the States of Maharashtra, Karnataka and Andhra Pradesh. The basin is roughly triangular in shape with its base along the western ghats, the apex at Vijayawada and Krishna itself forming the median.

Except for the hills forming the watershed around the basin, the entire drainage area comprises rolling and undulating country, a series of ridges and valleys interspersed with low hill ranges. Large flat areas of the type seen in the Indo-Gangetic plains are scarce, except in the delta. The interior of the basin is a plateau, the greater part of which is at an elevation of 300 to 600 m. Its general slope is eastwards. Great undulating plains divided from each other by flat topped ranges of hills are the main characteristics of this palteau. The hill sides are marked by conspicuous wide terraces except in the southern part where the hills are frequently crowned with great 'tors' or rounded hummocks of bare rock the result of constant weathering. The delta of the Krishna formed by deposits at the mouth of the river over past ages, consists of a wide belt of river-borne alluvium. The process of silt deposition at the mouth of the river is still continuing and the delta is gradually extending into the sea.

The basin receives its maximum rainfall during the south-west monsoons. The average annual rainfall in the basin is 78 cm. The forests occupy an area of about 11 per cent of the catchment.

The flood problem in part of the basin lying in Maharashtra is acute in the Sangli and the Kolhapur districts due to the fact that the abnormally high flood plain is used for purposes of habitation and cultivation. The damage in the Karnataka portion of the basin occurs in Belgaum and Dharwar districts from the river Malaprabha. In Andhra Pradesh, the flood damage is considerable in the delta areas.

Annual flows and Storage reservoirs

With the dawn of Independence, the country embarked on an ambitious programme of development of its water resources. We have succeeded in the programme to a considerable extent and till 1978, 517 reservoirs coming under major and medium projects have been completed creating a total storage of about 1,58,000 million cubic metres.

The average annual flows of the various rivers and the storage capacities created up to 1978 are listed in annexure 2.1. It may be seen that the total annual average flow is of the order of 1800 milliard cum. Of this, storages for 158 milliard cum have been created. This works out to about 9 per cent of the available flow. In terms of utilisable quantity of the surface water resources of India, it is about 22.5 per cent. Only the Damodar reservoirs and the Baigul reservoir include storages exclusively earmarked for flood control; in others, floods moderation to some extent is achieved by regulation. Construction of storage reservoirs on a number of rivers is being taken up.

ANNEXURE 2.1

*Average annual flows of river basins and storage capacities created upto 1978**

Sl. No.	Name of basin	Annual flow (average) in M.cu.m.	Cumulative gross storage (1978)	
			M.cu. m.	as % of annual flow
1	2	3	4	5
1	Indus	73305	18,050	25
2	Ganga	444053	30,286	7
3	Brahmaputra	590714	184	0·3
4	Godavari	118982	16,600	14
5	Krishna	68283	38,866	57
6	Kaveri	20695	7,420	36
7	East flowing rivers from Pennar to Krishna including Pennar and from Godavari to Mahanadi	23806	656	3
8	East flowing rivers from Cape Comerin to Kaveri & Kaveri to Pennar	17725	1,430	8
9	Mahanadi	66879	8,981	13
10	Brahmani & Baitarni	36227	630	2
11	Subarnarekha	10756	706	7
12	Damodar & Kasai	24032	4,721	20
13	Sabarmati	2883	1,269	44
14	Mahi	11829	3,420	29
15	West flowing rivers of Kathiawar & Kutch & Luni	15098	2,375	16
16	Narmada	42966	2,983	7
17	Tapi	16967	9,251	55
18	West flowing rivers from Tadri to Tapi	110877	369	0·3
19	West flowing rivers from Cape Comerin to Tadri	71981	9,430	13
		17,68,058	1,57,627	9

*CWC Memorandum on storages in River Basins of India January 1979—Statement I.

सत्यमेव जयते

III FLOODS—INCIDENCE & EXTENT

3.1. Definitions

3.1.1. According to the International Commission on Irrigation and Drainage (ICID) Multilingual Technical Dictionary on Irrigation and Drainage, "Flood" is defined as under:—

> "1601. FLOOD: A relatively high flow or stage in a river, markedly higher than the usual; also the inundation of low land which may result therefrom. A body of water, rising swelling and over-flowing land not usually thus covered. Also deluge; a freshet."

3.1.2. Floods occur due to a variety of causes in almost all river basins. The term "Floods" as dealt with in this report covers mainly the following situations:—

(i) streams carrying flows in excess of the transporting capacity within their banks, thus overflowing adjoining land,

(ii) backing up of waters in tributaries at their outfalls into the main river with or without synchronisation of peak floods in them,

(iii) heavy rainfall synchronising with river spills,

(iv) ice jams or landslides blocking stream courses resulting in the backwater overflowing river banks,

(v) synchronisation of upland floods with high tides,

(vi) heavy local rainfall,

(vii) typhoons and cyclones, and

(viii) inadequate drainage to carry away surface water with the desired quickness.

It would be observed that areas are also "flooded" when water due to rainfall and/or river spill is not able to drain off as quickly as considered desirable. This is considered a case of drainage congestion and termed "drainage" problem. Stagnation of water behind embankments due to insufficient capacity of drainage sluices falls in the same category.

Thus "drainage" forms a part of "floods" and the latter term should, in consonance with the context, be considered applicable to either or both.

3.1.3. Water accumulation on the ground surface is usually the result of heavy precipitation and/or overbank spill combined with deficiency of drainage capacity. As mentioned above, such situations sometimes also arise on the landside of embankments when the water stage in the main drainage channel (viz. the river) is high and the accumulated water cannot drain off into the river till a lower river stage is reached.

Similar conditions sometimes arise in municipal areas where drainage arrangements may be insufficient to deal with flows arising from heavy precipitation; such problems fall within the purview of the local body concerned.

3.1.4. Excess water on the land surface could be the result of waterlogging or stagnation in depressions and low areas. This can also result as seepage from canals, tanks and sub-soil flow from higher ground. Rise of sub-surface water is usually the result of irrigation and percolation from other sources. When the sub-soil water table rises to a level within the root zones of plants, oxygen supply is cut off, resulting in damage to or death of the plant; rise in sub-soil water table may also bring up salts to the surface, thus rendering land unfit for cultivation. In order to sustain the fertility of land and healthy cropping, it is necessary to lower the sub-soil water table; such a situation usually arises in major/medium irrigation schemes.

In this connection, the National Commission on Agriculture, 1976 has stated that, "Drainage is an integral part of an irrigation project without which a project would be incomplete and will not yield the desired results."

According to Irrigation Commission, 1972 "An area once damaged by waterlogging and salt efflorescence is difficult and costly to reclaim. We, therefore, urge that in formulating irrigation schemes, the instructions already issued in respect of making adequate provision for drainage should be strictly enforced."

Drainage of irrigated areas should, therefore, form a part of irrigation projects. Similarly, ameliorative measures taken in the case of land rendered unfit for agriculture due to permanent waterlogging or stagnation of water, should form a part of land reclamation.

3.2. Rainfall

3.2.1. The average annual rainfall in India is about 115 cm with significant variation in its areal distribution. The annual rainfall along the western coast and Western Ghats, the Khasi Hills and over most of the Brahmaputra valley amounts to more than 250 cm; the maximum is higher than 1100 cm. It is over 100 cm to the east of 78 degree longitude. In the area covered by the States of Punjab, Himachal Pradesh, Rajasthan and Gujarat, the annual rainfall progressively decreases westwards from about 60 cm to less than 15 cm over the extreme west Rajasthan. The annual rainfall is less than 60 cm with pockets of 50 cm in an elongated area over the Peninsula. Heavy freak rainfall does, however, occur even in the driest regions as happened in the Luni basin of Rajasthan and Saurashtra region of Gujarat in 1979.

3.2.2. Floods are caused by excessive rainfall in river catchments. Their magnitude depends upon the nature and extent of rainfall and the characteristics of the catchment. It may be that a sporadic fall of even heavy rain may not produce floods in the plains; on the other hand, this could cause flash floods in a hilly catchment. Per contra, moderately heavy rainfall occurring over a large area for a day or more may result in floods, specially when the catchment area is saturated.

3.2.3. The heavy spells of rainfall occur in association with the formation and movement of depressions or cyclonic storms which originate in the Bay of Bengal and sometimes in the Arabian Sea. Orographic features also have a striking influence on the rainfall as evidenced by the southern slopes of the Khasi-Jaintia hills, and the higher reaches of the Western Ghats. The pattern of rainfall and flood causing storms varies during the year.

January-February

This is the driest season and the rainfall is generally light. The area covered is the eastern coastal belt, parts of Assam and adjoining States, eastern Madhya Pradesh, and adjoining regions of Bihar and Orissa. In Jammu and Kashmir this rainfall accounts for 20 per cent of the annual average.

The precipitation is in association with the passage of low pressure systems, originating in the Bay of Bengal and moving in a westerly or north-westerly direction.

March to May

This is the season of thunder storms. The rainfall is low in the areas comprising Maharashtra, Madhya Pradesh, Uttar Pradesh, Rajasthan and Gujarat; it increases towards Kerala in the south and over Assam and the adjoining States in the east. In the north, there is a moderate increase over Jammu and Kashmir and adjoining parts of the Punjab.

The precipitation is due to tropical storms developing over the Bay of Bengal and the Arabian Sea. Those forming over the former move in a northerly direction, and cause considerable damage in the coastal areas of Andhra Pradesh and West Bengal. Storms forming over the Arabian Sea and those from the Bay of Bengal emerging into the Arabian Sea may occasionally recurve and cross the Kathiawar coast, causing extensive rain and floods in Gujarat and adjoining areas.

June to September

This is the principal rainy season for almost the entire country and accounts for 80 per cent or more of the annual rainfall, except in Assam and adjoining States, West Bengal, coastal Orissa and the Peninsula, south of 18° N, but excluding the area south of 12° N along the west coast. The orographic influence is dominant in the distribution of rainfall in this season as the prevailing winds blow almost at right angles against the Western Ghats and the Khasi-Jaintia hills.

The south-west monsoon sets in over Kerala in the first week of June, then extends northwards and covers the whole country by about early July. The monsoon starts withdrawing by about the beginning of September. The rainfall during the season is not necessarily continuous but occurs in spells sometimes lasting for almost a week. Most of the floods in the country occur during the monsoon and are generally associated with the following weather situations:

(i) Tropical storms and depressions,
(ii) Active monsoon conditions, and
(iii) 'Break Monsoon' situations.

The tropical disturbances (storms and depressions) often form in the Bay of Bengal and move across the country generally in west-north-westerly direction. They cause rainfall along their tracks, which can be locally heavy varying from 10 to 20 cm in 24 hours and may extend over thousands of square kilometres. If the disturbances are slow moving or stationary for a couple of days at any location, the total accumulation of rain water may occur over a number of days and be enough to cause floods. Also, these tropical disturbances sometimes recurve and may remain stationary over an area, thus resulting in excessive rainfall and floods. Generally in September depressions from the Bay of Bengal tend to recurve through Punjab and Uttar Pradesh and cause heavy rains and floods in the plains and hills of north India. There have been occasions when some of these depressions have moved over to Kashmir after recurving through Rajasthan or Punjab and caused floods there.

Strengthening of the monsoon current from the Arabian Sea results in heavy precipitation over the Western Ghats. Such strengthening in early parts of the season may cause floods in the

Kaveri river. Generally strengthening of the monsoon occurs in association with tropical disturbances. Formation of a depression off the Orissa coast often results in strengthening of the Arabian Sea monsoon off the Konkan area causing heavy rains in south Gujarat and Maharashtra as also over the upper reaches of the Godavari and the Krishna rivers, causing floods. Active monsoon conditions may also occur in different parts of the country in association with monsoon depressions and may often result in floods.

During the "Break Monsoon" period there is a general decrease in rainfall over the country. In such situations, however, rainfall increases over sub-Himalayan Bengal and upper Assam, thus causing floods in the Brahmaputra river and its tributaries lying in the eastern parts of the country. Such "Break Monsoon" conditions sometimes last a couple of weeks resulting in heavy rains over the north-eastern part of the country.

Some of the heaviest rainfalls on record have occurred during the monsoon season. The highest 24-hour rainfall at a station in the plains has been recorded as 100 cm on 2nd July, 1941 at Dharampur in Gujarat. The record 24-hour rainfall of 103.3 cm is still held by Cherrapunji.

October to December

The main rainfall belt is on the east of the country starting from Assam through the coast of Andhra Pradesh, Karnataka, Tamilnadu and Kerala, as also the southern part of the Peninsula; Kashmir also experiences some rainfall during this period. This is the wettest season as far as Tamilnadu is concerned.

The important rain producing systems of this season are the cyclonic storms which form in the Bay of Bengal. In the earlier part of the season, the storms travel north or north-eastwards causing widespread and heavy rainfall in West Bengal and Assam. During the latter part of the season, the storms usually strike Tamilnadu and Andhra Pradesh coasts resulting in heavy rainfall along their tracks. Sometimes these storms cross the Peninsula and emerge into the Arabian Sea, where they intensify and recurve, striking Gujarat or north Konkan coasts and causing floods. For example, Dwarka in Gujarat received almost the annual average rainfall of 32 cm in 24 hours on a day in November 1951 in association with a cyclonic storm. Sometimes as the severe cyclonic storms cross the coast, they give rise to 'storm surges' or 'tidal waves'. These may be upto heights of 3 to 5 metres, and cause severe and extensive damage. Such a cyclonic storm, for example, hit the Andhra Pradesh coast during November, 1977 when it almost flattened out the Divi and Bandar talukas of Krishna District. This resulted in loss of about 10,000 human lives, as also about 2.30 lakhs heads of cattle and 1.60 lakhs of other live stock.

3.2.4. Even though most of the precipitation and flood flows occur during the south-west monsoon season, the timings and years of heavy rainfall, floods and damages are not concurrent in all parts of the country. This is illustrated by the following table:

Area affected by floods (lakh hectares)

Year	Uttar Pradesh	Bihar	West Bengal	Assam
1954 . . .	13·5	25·0	4·2	31·5 (max.)
1956 . .	25·0	13·2	26·5 (max.)	6·0
1971 .	52·6	42·6 (max)	20·6	3·6
1978 . . .	73·4 (max.)	22·4	6·6	1·75

It is also quite common to see heavy flood damages and drought conditions in the same year in different parts of the country, sometimes even in the same state, for example, there were both heavy floods and drought conditions in the States of Uttar Pradesh and Bihar during the year 1979.

3.3. Rivers

Rivers rising in the Himalayas derive their flows from both rainfall and snow-melt. While snow-melt contributes a significant proportion of the total annual flow, it has not so far been possible to assess its contribution to floods. Coming down the slopes of the Himalayas, which are a young geological formation and consist of friable soil mantle, these rivers carry a lot of sediment which affects river regime, and damages land when the rivers bring down sand, and, result in silt accumulation in reservoirs. These rivers have high flood potential.

The Central India and Peninsular rivers on the other hand derive their flows from rainfall only, and, therefore, most of them are seasonal with very little flow in the non-monsoon season. These rivers, by and large, are stable, carry less sediment and cause less flood problems. While the Himalayan rivers tend to be perennial, the peninsular rivers are seasonal with negligible flows in the fair season. For example, while the maximum flood in both the Ganga at Farakka and the Narmada at Gardeshwar is of the order of 70,000 cumecs, the minimum flows are about 1,100 and 30 cumecs respectively.

3.4. Causes

3.4.1. In majority of cases, "flooding" is caused by a river overspilling its banks. This can be due to excessive precipitation, combined with inadequate channel capacity.

Overspilling can also occur due to obstruction in or aggradation of the river bed. The former situation arose in the Brahmaputra river after the earthquake of 1950, which caused extensive landslides and upheavels of land. Similarly, the beds of a number of streams in Assam have also aggraded resulting in river courses being higher than the general valley floors on the flanks.

Flooding can also result from inadequate waterways at rail and road crossings, or when there are encroachments in the flood plain.

Flooding also occurs at confluences of streams when the main river is in high stage and backs up into the tributaries and areas thereabout.

Changes of river courses and avulsions result in flooding by the river flowing over land outside its own channel. The Adhwara group of rivers in Bihar and the deltaic region of Orissa are examples of this type.

3.4.2. Floods originate in the watersheds of rivers in the mountains and the plains. The rainfall on hillsides flows down the slopes at great speed unless retarded. As the sheet flow gathers momentum, erosion sets in and soil is washed down, resulting in loss of productivity of land and increase in the sediment content in the streams. Vegetation in the form of forests or plantations acts as a retardant of the sheet flow. Forests also provide leaf cover which breaks the impact of the falling rain and reduces erosion. Roots of trees create conditions in the soil texture which are conducive to percolation. Thus, in areas under vegetal cover, soil erosion is reduced and low floods are moderated. Per contra, deforestation and lack of soil conservation and watershed management are causes contributary to flash floods and soil erosion.

3.4.3. As stated earlier, the soil mantle in the Himalayan watersheds is friable and unless there is enough vegetal cover, the soil is easily eroded and clogs the rivers. Earthquakes, landslides, shifting cultivation, road building and such other phenomena and human activities also result in increased erosion and sediment load in river courses. The Central India and Peninsular rivers rise and flow through areas which are geologically more stable. The sediment load in these rivers is comparatively small as a result of which they are less wayward.

In the flood plains, lack of proper control on land use and developmental works, result in flooding due to obstruction to natural flow.

3.4.4. Drainage congestion can result from heavy precipitation and lack of sufficient capacity in drainage channels. In the case of dug drains, this could be due to adoption of an insufficient factor of run-off, encroachments and lack of maintenance. In the case of natural drains, insufficient capacity could be the result of weed growth and obstructions like river-bed causeways.

Another cause for drainage congestion, as mentioned in para 3.1.3. *ante*, would be blockage of rain or flood waters behind embankments due to inability to drain off to the river.

The congestion in irrigated areas would, quite often, be the result of waterlogging due to heavy irrigation, sometimes aggravated by precipitation.

3.5. Geographical incidence

3.5.1. The main problems during the monsoon are flooding, drainage congestion and bank erosion. The problem is different from year to year and area to area. In general, India could be divided into four regions, as far as its rivers systems are concerned, namely:

(i) Brahmaputra region.

(ii) Ganga region.

(iii) North-west region.

(iv) Central India and Deccan region.

Brahmaputra Region

3.5.2. (i) In the Brahmaputra region the main rivers are the Brahmaputra and the Barak and their tributaries. They cover the States of Assam, northern portion of West Bengal and the North-Eastern States and Union Territories. The region receives very heavy rainfall, upto over 600 cm per year. The hillsides are friable and susceptible to erosion; the widespread practice of shifting cultivation known as "jhooming" accentuates the susceptibility. In addition, the region is subject to severe and frequent earthquakes, which cause numerous landslides and interfere with the drainage channels. As a result of the 1950 earthquake, for example, the bed of the Brahmaputra river silted up by about 3 metres upstream of Dibrugarh. The Dehang, which is the upstream reach of the Brahmaputra coming down from Tibet, silted upto as much as 6 metres; similar changes occurred in other channels. Extensive landslides seriously disturbed the drainage system. Excessive sediment in rivers has also led to large scale bank erosion.

The region is interspersed with a large number of streams, which inundate the intervening narrow valleys. The river beds in some cases are higher than the surrounding valley land and any breach or spilling causes deep flooding in the valleys. Drainage also is a problem because the river levels are usually higher than the levels in the valley.

(ii) The rivers Teesta (coming down from Sikkim), Torsa and Jaldhaka of the Brahmaputra basin flow through the northern portion of West Bengal. These rivers carry considerable amount of sediment and have a tendency to change their courses and cause flooding almost every year. A certain amount of bank erosion also occurs in Sikkim.

(iii) The rivers in Manipur frequently spill over their banks. Also the lakes in the territory fill up and spill during the monsoon season. Tripura has the problem of spilling and erosion of rivers.

The problem in other States and Union Territories in the basin arises mainly due to shifting cultivation and developmental works like roads etc. These result in washing down of sediment and bank erosion.

The main problems in the Brahmaputra region, therefore, are overspills, drainage congestion, bank erosion, landslides aggradation and changes in the river courses.

Ganga Region

3.5.3. The annual flood damages in the Ganga basin States account for about 60 per cent of the total in the country. The annual rainfall in the plains varies from 60 cm in the western part to about 175 cm in the eastern. The variation of rainfall in the slopes of the Himalayas is from about 125 cm to 185 cm.

The Ganga has a large number of tributaries, the important ones being the Yamuna, the Sone, the Ghaghra, the Gandak and the Kosi. They cover, partially or fully, the States of Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal, and the Union Territory of Delhi.

The northern tributaries of the Ganga rising in the hills, some in Nepal, cause most of the flood problems on account of the heavy flows and sediment they bring down from the Himalayas. Flooding takes place mainly in Uttar Pradesh, Bihar and West Bengal.

In Haryana, the marginal areas along the Yamuna get flooded. Though flood embankments have been constructed on both banks of the Yamuna in the territory of Delhi, flooding can occur due to breaches as happened during 1978. Sahibi Nadi and Najafagarh Drain also cause some flooding.

In the last 2-3 years, there have been spells of heavy rainfall in Rajasthan where the average rainfall is of the order of less than 15 cm per year. This caused heavy flooding and damage. It is, however, yet too early to forecast whether there is a change in the geographical incidence of the monsoon and whether and how this should be taken into account for dealing with flood problems of the area.

"Drainage" is a problem mainly in the south-western districts of Haryana, north and north-eastern districts of Uttar Pradesh, North Bihar and southern parts of West Bengal.

Thus, the flood problems in the Ganga region are mostly confined to the northern tributaries which bring in a lot of sediment, overspill their banks, and, change their courses. In Uttar Pradesh, frequent flooding is experienced in the Rapti, the Sarda, the Ghaghra and the Gandak. In Bihar the northern rivers like the Burhi Gandak, the Bagmati, the Kamala, the rivers of the Adhwara group and the Kosi experience frequent floods. The Bhagirathi, the Ajay and the Damodar rivers in West Bengal are flooding rivers.

Erosion of river banks also poses problems and occurs at places on the Ganga, the Ghaghra and the Gandak in Uttar Pradesh, and, in certain reaches of the Ganga in Bihar, and, West Bengal.

North-west Region

3.5.4. The north-west region is traversed by the tributaries of the Indus river, namely, the Jhelum, the Chenab, the Ravi, the Beas and the Sutlej. In the hill areas of Himachal Pradesh, the annual rainfall is about 175 cm, in Jammu and Kashmir it is about 75 cm. In the rest of the area, it decreases from about 60 cm in the east to less than 15 cm in the extreme western part of Rajasthan.

The Jhelum causes the main problem of flooding the town of Srinagar and the valley. The Chenab and the Ravi cause erosion in Jammu province.

The other rivers traverse the State of the Punjab, and parts of Himachal Pradesh, Haryana and Rajasthan. The flood problem in these states is generally of smaller order than those of the Brahmaputra and the Ganga basins. This is mainly due to storages having been constructed on the Beas and the Sutlej rivers; a storage is also planned on the Ravi. In the Punjab, however, choes (*i.e.* hill torrents) are a problem; cascading down steep slopes, they cause flash floods and extensive sand casting over agricultural land. The main problem is that of drainage and waterlogging in the States of Haryana and Punjab; this sometimes gets mixed up with irrigation drainage.

Central India and Deccan Region

3.5.5. In the Central India and Deccan region, the important rivers are the Narmada, the Tapi, the Mahanadi, the Godavari, the Krishna and the Kaveri. These rivers, by and large, have well-defined and stable courses and usually adequate bankful capacity. These rivers fully or partially cover the States of Madhya Pradesh, Gujarat, Maharashtra, Orissa, Karnataka, Tamilnadu, Kerala and Andhra Pradesh. While the area receives its rainfall mainly during the south-west monsoon coastal areas of Andhra Pradesh and Tamilnadu receive north-east monsoon also. The annual rainfall over the Western Ghats can be as high as 500 cm; in the remaining area it varies from about 75 cm to 125 cm.

While the region as a whole does not have a serious flood problem, there is occasionally flooding in some of the rivers, like the Brahmani, the Baitarni and the Subarnarekha in Orissa. Another problem arises in the deltas of the Brahmani, the Baitarni and the Mahanadi where flood waters intermingle and are difficult to drain out on account of the low terrain. This also causes drainage congestion.

The Tapi and the Narmada sometimes experience high floods. The floods in the Tapi will now get moderated by the Ukai Dam. It is expected that the construction of storage reservoirs on the Narmada also, will result in substantial mitigation of the flood problem in its basin.

In Andhra Pradesh a number of rivers empty into the Kolleru Lake, thus submerging marginal lands. The main problem is lowering of the Lake waters for making available areas for cultivation.

The rivers in Kerala are small. All the same they can cause substantial damage when they are occasionally in high floods.

In the delta areas of this region there is the usual problem of sediment deposition, raising of flood levels, drainage congestion and synchronization of river floods with sea tides.

3.6. Extent

The figures of annual damage by floods and drainage congestion are reported to the Central Water Commission by the states; these are available from the year 1953. The maximum area damaged in any one of the years is assumed to be the area liable to floods in the state. The total of such maxima of the various states is considered to be the area liable to floods in the country. Based on this criterion, it was earlier estimated that an area of about 25 million ha was liable to flooding.

During the present decades, however, a number of areas, not hitherto considered as liable to floods, have been affected by floods, as for example, some areas in Gujarat and Rajasthan. Adopting the same criterion of adding of maximum area affected in each state in any one year during the period 1953 to 1978, the area liable to floods has now been assessed at about 34 million ha; reasonable protection has been provided to about 10 million ha—details in Annexure 3.1.

3.6.2. It is, however, clear that while the maximum area flooded in any one year may broadly indicate the degree of the flood problem in a state, it does not strictly indicate the area "liable" to flooding. Since a number of streams flow through every State, annual flooding is not geographically co-extensive, as different areas may be, and often are, flooded in different years from different streams. Therefore, for the purpose used at present, the aggregate of different areas, flooded in any year during the period of record in the geographical limits of State, only could be considered as "liable" to floods.

It is but certain that such an aggregate would be more than 34 million ha mentioned above. Until this aggregate is worked out by the States, the present figure of 34 million ha is being taken into account.

3.6.3. The total of the unprotected and protected areas, flooded in any year, constitutes the area liable to floods. If, therefore, the 34 million ha did not include any area out of the protected 10 million ha, the total area liable to flooding would be 44 million ha. It is, however, known that during the years of high floods at least some protected areas also are affected due to failure of some protection works; the extent of such areas has not been reported by the States. Assuming such area, already accounted for in the 34 million ha, to be about 4 million ha, the area liable to floods would amount to about 40 million ha; this however, does not take into account the likely increase referred to in the last para.

3.6.4. The figures of damage being collected by the States comprise the aggregate of the following, but not categorywise:—

(a) *Floods*:

   (i) unprotected areas flooded.

   (ii) protected areas flooded due to failure of protection works.

   (iii) areas between the embankments and the river where embankments have been constructed.

(b) *Drainage congestion*:

   (i) In unprotected areas.

   (ii) behind embankments due to tidal lockage or precipitation and|or spills through the river sluices on account of inability to drain off because of high state in the river and|or inadequate capacity of drainage sluices.

For preparing projects for new works, however, figures needed are those in sub-item (i) of both (a) and (b) above. In the case of areas under sub-item (a) (iii) no protection work can be planned and these areas would continue to suffer flood damage.

Items (a) (ii) and (b) (ii) are such where initial protection works have been provided and what may be needed would be strengthening|augmentation of the same works. They do not, therefore, form part of the data required for formulation of new flood projects.

It is, however, desirable that, wherever feasible, damage figures be collected under the various sub-items mentioned above, so that each of the categories could be used for an appropriate purpose. The methodology of collection is detailed in Chapter IX.

3.6.5 It is well understood that protection cannot be provided to all the areas subject to flooding. This is due to topographical and economic factors. It is also clear that the same degree of protection need not be provided to all types of areas considered liable to flooding. The degree of protection would depend upon the criteria that may be fixed for providing protection to various types of areas. The criteria would normally depend upon the damage potential and possibility of loss of human lives.

3.6.6. As mentioned above, the area that could be protected would be less than the total area liable to floods, and would depend upon the degree of protection proposed to be provided for different types of areas. If for example, protection is provided on the basis of frequency of flooding, areas would be categorised as protectable under frequencies of 25, 50 or 100 years or of a higher order. These totals could be called the "protectable" area. The extent would need to be worked out.

Protection may lead to development and therefore, changed damage potential. Longer-term hydrological data may also require review of the area likely to be affected. The extent of "protectable" area should, therefore, be periodically reviewed in the light of changed conditions.

3.7. Magnitude of future works

3.7.1. In view of the increasing trend of flood damages it is but natural that people would be interested in the progress achieved in flood protection. This can be measured only against a target. The "protectable" area is the correct target for such comparison. The exact extent, as of present, needs to be worked out.

As explained in para 3.6.3, the area liable to floods may, for the present be taken as 40 million ha. This will need to be reviewed in the light of the factors mentioned in the foregoing paragraphs. The present "protectable" areas could then be worked out after actual surveys and application of the design criteria. In order, however, to get an idea of the magnitude of the future investment needed on flood protection works, we may, for the present assume 40 million ha as the area "liable" to floods.

It had so far, been assumed that about 80 per cent of the "flood" prone area could be provided with reasonable protection; a study carried out by the Ganga Flood Control Commission indicates this percentage to be reasonably correct. Accordingly, the "protectable" area may be placed at about 32 million ha. As reasonable protection has already been provided to about 10 million ha (vide Annexure 3.1), the residual area to be protected would be about 22 million ha.

3.7.2. It is difficult to forecast the unit cost of protection. Further, works like town protection, raising villages, anti-erosion, and, multi-purpose storages etc. would need to be included.

The Central Water Commission had in their "Flood and their control in India, 1977" estimated an outlay of Rs. 2000 crores for providing protection to the residual area then estimated at about 11.5 million hectares. Taking that as a guide, and, considering the addition of other types of works, mentioned above, the future outlay, at present-day prices, may be of the order of Rs. 5,000 crores.

ANNEXURE 3·1

Areas liable to floods and expected to be protected (1978)

Area : lakh hectares

Sl. No.	State	Area liable to floods	Area protected
1	Andhra Pradesh	13·9	7·000
2	Assam	31·5	13·050
3	Bihar	42·6	15.660
4	Gujarat	13·9	3·620
5	Haryana	23·5	10·950
6	Himachal Pradesh	2·3	..
7	Jammu & Kashmir	0·8	0·120
8	Karnataka	0·2	0·010
9	Kerala	8·7	0·113
10	Madhya Pradesh	2·6	..
11	Maharashtra	2·3	0·010
12	Manipur	0·8	0·730
13	Meghalaya	0.2	0·750
14	Orissa	14·0	3·510
15	Punjab	37·0	24·070
16	Rajasthan	32·6	0·160
17	Tamilnadu	4·5	0·295
18	Tripura	3·3	0·091
19	Uttar Pradesh	73·36	7·390
20	West Bengal	26·5	10·010
21	Delhi	0·5	0·226
22	Pondicherry	0·1	0·002
	TOTAL	335·16	97·767
	Say :	34 million ha	10 million ha

Source : Ministry of Agriculture & Irrigation (Department of Irrigation) : Final Report of the Working Group on Flood Control, November, 1978.

सत्यमेव जयते

IV ANALYSIS OF AVAILABLE DATA ON FLOOD DAMAGES

4.1. Introduction

Flood becomes a problem whenever it causes damage to crops and property and endangers life. The extent and magnitude of the problem can be assessed in terms of the different types of damages brought about by it. Hence it becomes necessary to analyse the available data on flood damages. Such analysis should throw light on the trend of area affected and of damages or losses inflicted, composition of damages in terms of damage to crops, dwellings and public property, regional distribution aspects, causal factors and their long term impact on the economy. This background information will also be helpful in providing a better understanding and appreciation of a number of issues which are being dealt with in subsequent chapters.

4.2. The available data

4.2.1. Data on flood damages are being collected for quite some time by State Governments as part of relief administration. Major components of these data relate to total area affected by floods, number of villages and population affected, cropped area affected, loss of crops, human lives, cattle and private property and damage to public utilities. On the basis of returns received from the States from time to time, the Central Water Commission (CWC) has been compiling damage data at the national level. Figures from 1953 to 1978 are available with the CWC on a continuous basis. The 1979 data are also available with them but these are tentative.

4.2.2. In response to our questionnaire, several State Governments furnished data on flood damages for a number of years, however, it was found that these were not continuous. Hence the Commission drew upon the country-wise and State-wise data maintained by the CWC. Though some discrepancies between the two sets of figures for some years have been observed, these are not considered significant from the point of view of our analysis because the trend evinced by both series were found to be more or less similar. It is, therefore, felt that the findings of the time series analysis based on CWC data, attempted in this Chapter, would not be significantly different from those based on State data in case such data were available.

4.2.3. It may be stated at the outset that the available data which we have used suffer from many deficiencies. These generally stem from factors like inability of the primary reporting agencies to assess the magnitude of the flood damages objectively, human bias in reporting, arbitrary methods adopted in estimating yields and crop values, absence of a suitable mechanism for supervision, checking and lack of coordination at the lower level between concerned departments of the Government. Possibility of deliverate distortions of these statistics with a view to gaining some governmental assistance and concessions in some areas in some years also cannot be ruled out. An equally important factor which has affected the quality of the data is the failure to distinguish between causes of inundation like overspilling of banks, drainage congestion, local storms, cyclones etc. Besides, no distinction is being made between flood damages in protected and unprotected areas.

4.2.4. In view of the above weaknesses of the available data any conclusion drawn from the analysis should be interpreted with caution. However, it should also be noted that the deficiencies, to the extent that these are present throughout, are less significant for a trend or time series analysis. Thus, these limitations notwithstanding, it is possible to make use of the available data to identify or discern major trends underlying them, if any.

4.3. The overall picture

4.3.1. *All India*

During the period 1953—78, on an average, about 8.2 million hectares of area was affected by floods every year of which 3.5 million hectares *i.e.* 42.7 per cent were crop lands. If only the seventies are considered, the area affected was more. The annual average for the period 1970 to 1978 worked out to 11.9 million hectares in respect of total area affected and 5.4 million hectares for cropped area. The former constituted 3.9 per cent of the reporting area in the country while cropped area affected constituted 4.3 per cent of the total net sown area. For major flood prone States, relevant figures for the seventies are much higher *e.g.* 12 per cent and 10 per cent for Bihar, 10 per cent each for Uttar Pradesh and 15 per cent and 9 per cent for West Bengal.

4.3.2. Besides crop losses, floods cause considerable damage to houses and property as also losses of human and cattle lives. On an average 9.25 lakh houses were damaged every year during the last 25 years, losses of human lives amounted to 1240 and of cattle 77,000. These figures included deaths due to cyclones and accidents like capsizing of boats. Railways, roads, communication lines, public utilities etc. also, suffer considerable damages during high floods.

4.3.3. Average figures, however, conceal large year-to-year variations. For instance, in case of total area, while in 1965 only a million hectares were affected, the spread was many times more during the three years 1976 to 1978—over 17 million hectares. About 3,500 people lost their lives in 1968 as against only 34 in 1953. The picture would be similar in the case of other losses also.

4.3.4. *State-wise distribution*

Five States *viz.* Bihar, Uttar Pradesh, West Bengal, Orissa and Assam can be identified as more prone to floods. Gujarat, Andhra Pradesh, Tamilnadu and Rajasthan have also suffered in recent years. In addition, acute drainage congestion is experienced in parts of Uttar Pradesh, Bihar, West Bengal, Haryana, Punjab and deltaic areas of Andhra Pradesh and Orissa. Within a State, certain parts suffer more than others, as for example, north Bihar, eastern Uttar Pradesh and the Assam valley. In Orissa, the flood problem is confined mostly to the three districts: Cuttack, Puri and Balasore, and in West Bengal to central and southern parts. In other States the problem is very much localised. It is also seen that the States of Uttar Pradesh and Bihar suffer much more frequently than others. During the years 1971—78, for example, Uttar Pradesh and Bihar were seriously affected six times and five times respectively, whereas Orissa, Andhra Pradesh and West Bengal were affected three times. Gujarat and Tamilnadu, twice and Rajasthan and Assam only once (Annexure 4.1).

4.3.5. There has been a significant difference in the pattern of area affected and damages during the three years 1976 to 1978. In the early period, the five States *viz.*, Uttar Pradesh, Bihar, West Bengal, Orissa and Assam accounted for 75 per cent to 80 per cent of damages both in terms of area and monetary losses. During the triennium 1976—78, however, floods and calamities of that type were more widespread, affecting many more States outside the traditional flood zone. The latter group included Andhra Pradesh and Rajasthan and to a lesser extent, Gujarat and Haryana. The share of flood damages of second group taken together went up from 20—25 per cent to about 50 per cent of the total damage in the country. This shows that a part of the rise in flood damages in recent years has been due to incidence of flooding in areas not usually affected.

4.3.6. As already indicated, the data so far available for 1979 are tentative. It shows that this year was markedly different from others. The extent of total area and crop area affected were only 4.0 million hectares and 2.1 million hectares compared to the average figures of 8.2 and 3.5 million hectares respectively during the previous 25 years and 17.4 and 10.05 million hectares respectively in the preceding year. The year 1979 experienced severe drought in several parts of the country. Rainfall being sparse, there was hardly any flood in the traditional flood zone. However, some isolated instances of severe damages and loss to lives and property, particularly houses, were reported from a few States like Rajasthan, Andhra Pradesh, Tamilnadu and Gujarat. In Rajasthan the losses were due to heavy precipitation in the Luni basin. In Andhra Pradesh and Tamilnadu, these were due to cyclones; and in Gujarat it was the failure of the Machhu II dam consequent upon excessive rainfall in the catchment. In view of the tentative nature of 1979 data on flood damages, and non-availability of other relevant data (for that year) used in the following analysis, we have confined the detailed analysis to the period upto 1978.

4.4. Trends in areas damaged

4.4.1. One recognized method of identifying the trend underlying any series of data is that of the moving average. It helps to remove the aberrations caused by unusual events and smoothen the annual series. A five-year moving average is considered appropriate. Details of area affected etc. are shown in Annexure 4.2. From these, the following inferences can be drawn.

4.4.2. *Total area*

The general trend (Chart I) is one of increase over the years; even so, three facets of it are easily discernible:

(i) a gradual decline in area affected during 1953 to 1965;

(ii) a sustained and marked increase in area affected between 1966 and 1971; and

(iii) a steadily increasing trend at a very high level marked by sharp annual fluctuations from 1972 onwards.

4.4.3. *Cropped area*

Though the overall trend in cropped area, like that in total area, is one of increase, there is some difference in the direction of change during the early period 1953—65 (Chart II). While the total area affected showed a gradual decline, the cropped area remained remarkably steady during this period. Thereafter, as in the case of the former, there was steady increase. During the last three years from 1976 to 1978 while the total flooded area remained steady at 17 million hectares, the cropped area showed significant increase from year to year.

4.4.4. A summary statement for the period 1953—78 is presented below:

TABLE 4.1

Area affected by floods (lakh hectares)

Period	Cropped area		Total area	
	Average	Maximum	Average	Maximum
1953-65	21·0	54·0	59·6	111·7
1966-70	33·6	48·5	75·1	95·4
1971-75	46·9	76·0	91·1	137·2
1976-78	86·6	100·5	175·7	178·9

The conclusion that emerges from the above analysis is that the total area as well as the cropped area affected have increased in recent years.

4.4.5. There could be several reasons for the increase in the area affected in recent years despite the protection measures undertaken. It has not been possible to quantify them due to non-availability of supporting data. One possibility could be a change in meteorological conditions for which we do not have enough evidence. A review of the rainfall pattern during the south-west monsoon in the country from 1976 to 1978—a period associated with severe floods—did not yield any firm evidence that these were years of unusually high rainfall. In a few cases some studies made by the CWC based on river gauge data, however, provide some supporting evidence for the increasing trend of flood levels. A trend analysis of gauge discharge data on the Yamuna at Paonta, Mavi and the old railway bridge at Delhi revealed an upward trend in peak gauge values from 1970 onwards. No such visible trend, however, was observed in respect of Kalanaur and Okhla sites on the same river. Again, a study of gauge data for the Brahmaputra river at Dibrugarh showed that the highest level was rising during the period 1913 to 1978 at an average rate of 30.5 cm in ten years; but there was no discernible trend either in peak gauges or discharges on some sites on the Ganga river. Deforestation and denudation of soil cover that have been taking place on an ever-increasing scale are known to facilitate quicker and increasing runoff of rain water. This in turn may add to the peak flood discharge in minor and medium floods. There is also evidence that development activities like expansion of rail and road net work, establishment of irrigation systems, embankments, industrial estates and residential complexes etc. undertaken in the country since Independence, while bringing large benefits, have also adversely affected country drainage, thereby aggravating the drainage problem. The infiltration rate and the amount of rain water seeping into the ground have decreased due to occupation of land by structural works and large scale urbanisation. The cutting of valley storage by embankments can also result in increase in river discharge and flood levels. Assam, Bihar and West Bengal have reported rise in beds of some of their rivers although quantitative details have not been furnished. This results in higher flood level with respect to a given discharge. There have been cases of breaches and overtopping of embankments which tend to result in damages in protected areas. However, separate figures on this are not available. Lastly as indicated in para 4.3.5 areas not usually subject to flooding have been affected and this has been an important reason for the rise in flood affected areas in recent years.

4.5. Trends in flood losses

4.5.1. Available data relating to flood damages are in current prices. Over-all trend of flood damage during the period 1953—78 in current prices has been one of sharp increase, the value of damages increasing from about Rs. 54 crores and Rs. 58 crores in 1953 and 1954 respectively to about Rs. 1200 crores in 1977 and Rs. 1091 crores in 1978. The increase was nearly 21 times compared to the early fifties. A significant part of this rise was due to rise in price level itself. The ever-changing prices also render annual figures of damages non-comparable. If they are to be made comparable, they need to be expressed in terms of constant prices. It is considered appropriate to convert the damage data in terms of 1952-53* prices in view of the fact that the National Flood Control Programme was launched in 1954 and, hence, a continuous series with 1952-53 as base would provide a suitable index of progress. Data accordingly adjusted are presented in Annexure 4.3. Price indices of all commodities and agricultural commodities** have been used for adjusting the annual figures.

4.5.2. *Total damage*

The overall trend of flood damages during the period 1953 to 1978 was one of increase as in the case of area (Chart I). On an average and at constant prices, these were estimated at Rs. 51.2 crores in the fifties, Rs. 92.2 crores in the sixties, Rs. 152.4 crores during the first five years of the seventies and Rs. 260 crores in the triennium 1976—78. As in the case of area, three distinct phases of the trend could be easily identified. During the first phase covering the period upto 1965, not only where the flood losses comperatively lower, but the general tendency also was one of gradual decrease. The following six years, 1966 to 1971 witnessed a sharp increase in flood damages. During this phase, besides flood losses being heavy, every year appeared to set a new record in flood havoc. The rising trend hardened at the high level reached in 1971 and ruled steady during the years 1972 to 1975. Thereafter in conformity with the increase in flood-spread, there was again a further increase in flood damages during 1976—78. A disquieting fact revealed by annual data is the enormous increase in flood damages from 1971 onwards. While the peak points of this phase remained unmatched in any of the years prior to 1970, even the trough level damage of 1972 was much higher than damages reported in most of the pre-1970 years.

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*This year happens to be the base year of one whole sale price index series.

**Index of prices of agricultural commodities is worked out by the Directorate of Economics and Statistics, which is a weighted average of all agricultural items included in the index system.

4.5.3. *Damage to crops and property*

The two components of the flood damage data, namely, (i) crop damage and (ii) damages to property, private and public, showed a similar pattern, *viz.*, a marginal decline or even trend in the early years, a perceptible increase from 1966 to 1971, a levelling off at about the 1971 level, and a sudden and steep rise to new heights in the last three years which was particularly marked in the case of property component (Charts II & III).

4.5.4. Certain other interesting trends are also observed in the series relating to crop damages and damage to houses and public utilities. The following table presents the salient aspects of these changes and trends:

TABLE 4.2

Monetary value of flood damages (at constant prices)—All-India (Rs. crores)

Period	Crop damage	Damage to property			Aggregate damages
		Private houses	Public utilities	Total	
1950—65 .	38.8	8·1	4·3	12·4	51·2
1966—70 .	61·5	14·1	16·6	30·7	92·2
1971—75 .	101·6	17·0	33·8	50·8	152·4
1976—78	156·8	30·6	72·1	102·7	259·5

There has been a five-fold increase in total damages in the later seventies compared to 1950—65. This was brought about by a four-fold increase in crop damages and an eight-fold increase in property damages. However, while the total damage has been steadily increasing, the proportionate share of crop in total damages decreased from 76 per cent to 60 per cent during the period and that of property damages increased from 24 per cent to 40 per cent. Within the property component again, the two constituents *viz.* house damage and damage to public utilities showed different trends. Over the two decades, while house damages registered a four-fold increase, damages to public utilities increased many times more—nearly 17 times. When both these items are compared to total damages, it is observed that while the proportionate share of house damages declined from 16 per cent to 12 per cent over the period, that of public utilities increased from 8 per cent to 28 per cent. One at the major factors in recent increase in damages has thus been identified as damage to public utilities which continues to show a steady rise.

4.5.5. One apparent cause for the rise in flood damages is the increase in total flood affected area. However, as can be seen from figures in this Chapter, the percentage rise in monetary value of damages has been much more than that in the area figures. In other words, floods of a given order have caused progressively higher damages. One reason for this is the increasing encroachments into the flood plains. This is reflected by the fact that the relative increase in crop area affected has been much more than that in the total area. The proportion of cropped area affected to total area flooded which was about 30 per cent in the fifties increased to 40 per cent in the sixties and to 50 per cent during the current decade. It, therefore, appears that extension of cultivation to flood prone areas has been on the increase and this has been a contributory factor to the rise in flood damages.

4.5.6. Rise in the price level may be regarded as another significant factor. In view of the steady increase in prices during the past two decades, a significant part of the increase in monetary value of flood damages, which are in terms of current prices, could be attributed to this factor. The share of its contribution can be seen from Annexure 4.3. Some quinquennial averages extracted from that table are presented below to illustrate the point:

TABLE 4.3

Monetary value of flood damages at current and constant (1952-53) *prices*

(Rs. crores)

5 Year average	Total damages		Crop damages	
	at current prices	at constant prices	at current prices	at constan prices
1953—57 .	60·86	63·45	43·52	45·30
1968—72 .	322·60	137·76	206·22	86·02
1974—78 .	845·13	207·43	520·53	127·15

It would be seen that while the average annual damages at current prices increased 14 times between 1955 and 1976, the rise was only 3.3 times in terms of constant prices. Also, the price factor contributed as much as about 75 per cent of the rise in monetary value of damages between 1952-53 and 1976. The picture is broadly similar in respect of crop damages as well. It is clear that rise in prices has been a very important cause of rise in flood damages.

4.5.7. Other reasons could be (i) increase in agricultural productivity, and (ii) increase in private and public investment in houses, property, land development and infrastructure development etc.

4.5.8. For isolating the effect of the above factors, the damage data at constant prices relating to crop production and private and public property in Annexure 4.3 have been reduced to unit area basis with the help of relevant data relating to area given in Annexure 4.2. The resulting figures are given in Annexure **4.4.**

4.5.9. *Damage per unit areas*

The general trend of damage per unit area (that is, per hectare) is one of firmness marked by marginal fluctuations during the period 1953 to 1965 and thereafter a sharp and sustained increase. This is in conformity with what was observed with respect to area and total damage. However, the 'crop component' and 'house and property component' manifest some differences in the pattern. In the case of the 'crop-component' unit area figures of damage showed a steady decline from Rs. 250 per hectare to Rs. 140 per hectare between 1955 and 1963 and thereafter a moderate increase to Rs. 200 by 1970 and further to Rs. 216 by 1973. There was, however, a marginal decline in these values in the following years. Crop damage per unit area was thus moderate in recent years compared to the fifties. This is as expected because agricultural productivity in flood prone areas has not shown any marked increase. Besides, extension of cultivation to more flood prone and less productive lands is also responsible for the moderate figures.

4.5.10. In the case of 'house and property component' the unit area damage due to floods was comparatively small (between Rs. 20 to Rs. 35) during 1955 to 1965 but there was a steady and sharp rise thereafter to Rs. 105 by 1970, and further to Rs. 140 by 1976. The increase in such damages was four times between 1955 and 1976. This increase has been more marked in the case of public utilities, having gone up by 17 times during the same period. Such damages which accounted for only about 8 per cent of total damages in the early period, are now responsible for more than one fourth of the damages. In other words, progressive rise in damage to public utilities like roads, canals, embankments, etc. has been an important reason for the increase in flood damages.

4.5.11. On the whole, the major factors contributing to the progressive rise in monetary value of flood damages were an increase in the magnitude of flood itself, increasing encroachment into flood plains for agricultural and other purposes and rise in prices which was almost continuous.

4.6. State-wise analysis

4.6.1. Five major flood prone States, namely, Uttar Pradesh, West Bengal, Bihar, Orissa and Assam accounted for 82 per cent of the total area affected and 75 per cent of the aggregate damages during 1971—75. The analysis is, therefore, limited to these States. Five statements in respect of these States presenting data similar to those presented earlier for the country as a whole are exhibited in Annexures 4.6. to 4.10. The broad trends in area submerged and damages sustained can be seen from the graphs enclosed. An abstract statement, giving relevant information in respect of the five States for four periods, namely, 1950—65, 1966—70, 1971—75 and 1976—78 is presented in Annexure 4.5 so as to highlight the points of similarity as well as differences indicated by the States series compared to all-India trends.

Uttar Pradesh

4.6.2. The State accounted for 24 per cent of the total flooded area and 23 per cent of the total damages in the country during the period 1971—78. The eastern half of the State is more vulnerable and some part or other of that area gets affected by floods almost every year. The proportion of cropped area in the total area affected increased from 45 per cent during 1953—65 to about 55 per cent during 1971—78.

4.6.3. *Total area*

As at the national level, in the State too there was a gradually declining trend during 1956—65, which was reversed in 1966. Floods were more frequent and more severe during 1966—71 but the situation improved somewhat thereafter. Again the years 1976 and 1978 witnessed serious floods, of which that of 1978 was of unprecedented magnitude. These two floods brought about an upward trend in total area affected. Trends in the cropped area and the non-cropped areas over the period were broadly similar.

4.6.4. *Damages*

Flood damages were generally low in the early years prior to 1965, particularly so in respect of property. In contrast, damages whether in respect of crop or property reported during 1966—71, showed a steady rise, and, thereafter, despite the few years respite from floods, the trend was one of firmness upto 1975 and a further increase from 1976.

4.6.5. One peculiar feature of the overall situation in Uttar Pradesh was that if the 1978 floods were to be ignored there was no marked difference between the pre-1965 and the post-1965 position in respect of the extent of area affected. This was somewhat different from the all-India pattern which showed a sustained and sharp increase all through from 1965 onwards.

4.6.6. The trend in damages in post-1965 period was, however, different and the sharp increase observed was mainly due to a high level of damage to crop and property reported in 1971, 1976 and 1978. The figures of unit area damage for cropped and non-cropped areas showed a sharp increase particularly in the last five years.

Bihar

4.6.7. The State accounted for about 17 per cent of the total flood affected area in the country and 23 per cent of the aggregate damages in recent years. Most of the areas seriously affected are situated to the north of the river Ganga. A number of rivers traverse these areas which include the Gandak, the Burhi Gandak, the Bagmati and the Kosi. They are all known for their flooding propensity.

4.6.8. *Area*

There was an upward trend in area affected by floods in the State after 1965. The increase was sharper during the seventies. A similar trend was observed in the case of cropped area too. Another noteworthy feature of area trends was the significant decrease in the proportion of cropped area in the total area affected from about 50 per cent during 1950—70 to less than 40 per cent during 1971—78. This was in marked contrast to the trend showed by the all-India figures which indicated an increase during the period.

4.6.9. *Flood damages:*

If increase in area affected was steady during 1966—78, increase in damages caused was more marked. Area, as also unit area damages, contributed to the increase in the overall damage observed in the seventies. The striking feature, however, was the disproportionate increase in the non-crop component—both area and damages—during this period which claimed for itself a major share in the phenomenal increase in the overall damages. While at the national level, the increase in non-crop area and non-crop damages in the seventies, compared to the period 1953—65 was only 1.5 times and 6 times respectively, it was 2.33 times and 11 times respectively in the case of Bihar. The increase in non-crop damages has thus been extraordinarily high.

West Bengal

4.6.10. During the last eight years the shares of the State in the total area affected by floods and total damages was 10 per cent and 7 per cent respectively. Unlike the other States considered here, the crop area affected in West Bengal constituted only one-third of the total area. In the early years it was even less, about 23 per cent.

4.6.11. *Area*

The 5-year moving average of total area, cropped area and non-cropped area affected indicated an increase in the mid-fifties followed by a drop, a second increase and decline from 1966 to 1974 or so, and a third phase of increase from 1976. The most marked feature of the movement was the increase centred around 1970, brought about by three major floods, almost in succession, in 1968, 1970 and 1971. Movement in crop area and non-crop area showed a moderately increasing trend.

4.6.12. *Damages*

In marked contrast to the trends revealed by area figures, all the three series of data relating to damages (corp, property and total) showed a completely disproportionate increase during 1966 to 1974 with their hump around 1970. The unit area damage figures for crop areas and non-cropped areas also showed the same trend.

Orissa

4.6.13. The State accounted about 6.5 per cent of the total area affected in the country and 5 per cent of total damages from 1971 onwards. The proportion of cropped area in the total area affected was only about 40 per cent for a long period from 1955 to 1970. However, in the seventies such lands constituted 54 per cent of the total. The trend of area affected and damages suffered by the State was very much similar to those observed in West Bengal. Two flood cycles were observed during the period, first one from 1955 to 1964 with its peak around 1960 and the second, a much bigger one in magnitude and severity with its hump around 1972. From 1974, the proportion of cropped area affected was more, even though the magnitude of floods and the total area affected were just average. Damages reported, particularly the property component, however, were disproportionately high.

4.6.14. The series of per hectare values of damages—crop, property and aggregate—showed an interesting trend. While unit value of crop damages registered a decline in recent years, the unit value of property damage indicated a steady increase from 1964, and surprisingly enough it exceeded the unit value of crop damages from 1972. The increase recorded in this particular series since that year, was incredibly steep which incidentally gave an upward bias to total damages per hectare. The average property damage per hectare affected was as much as Rs. 543 during 1976—78 compared to Rs. 44 during 1955—65. These figures were much higher than the corresponding all-India and State figures.

Assam

4.6.15. Assam lies in the Brahmputra basin. The State accounts for 8 per cent of the total flooded area and 2 per cent of the flood damages in the country. While only about 13 per cent of the total affected area was under crops during 1953—65, the proportion of such lands increased to more than 50 per cent during the late seventies.

4.6.16. *Area*

The trends in area and damages exhibited by the State were distinctly different, compared to the other States considered. Though floods were frequent all through the last 25 years, there was no definite indication that the situation had aggravated in recent years. In fact the State experienced more damaging floods during the period before 1967 than thereafter. Trends in total area and cropped area affected exhibited a marginal increase and that in non-cropped area, a marginal decline.

4.6.17. *Damages*

The relevant figures in respect of damages, whether to crops, property or overall, indicated that losses sustained during the pre-1967 period were heavier than those during the later period. However, the trends exhibited by the smoothened series relating to these damages appeared somewhat indistinctive mainly due to the sharp year-to-year fluctuations. In contrast, the series relating to per-hectare damages clearly revealed a downward trend which was more pronounced in the case of crops. Trends evinced by Assam, both in respect of area and damages, were out of tune with those manifested by other States.

4.6.18. *Conclusion*

It is evident from the foregoing analysis that the only States where the trends in area and damages were a close reflection of all-India trends were Bihar and Uttar Pradesh. Both States recorded sizable increase in area and a more than proportionate increase in damages, particularly with respect to houses and public property. Unit area damage figures also showed a steady rise more markedly in Uttar Pradesh. The pattern in West Bengal and Orissa was slightly different. The contribution of these two States to the increase in the area affected and damages was significantly less from 1976 onwards than in earlier years. Trends in unit area damages in these two States showed some divergence. While West Bengal reported sizeable decrease in crop and non-crop values, in Orissa, the non-crop component showed an extraordinary increase. In Assam, the trends both in area and damages revealed rather a stable situation despite the frequent occurrence of floods. Over the period the damage per unit of cropped area showed a decline.

4.7. Flood damages and economic welfare

4.7.1. The ever-mounting flood damages to agriculture and property revealed by the available data would have made a dent on the economic well-being of the people. To begin with, we look into the aggregative data relating to national and State domestic product from agriculture (Annexure 4.11). Subsequently we examine the figures at the district level.

4.7.2. At the all-India level, a comparison of the crop damage data with the series relating to net domestic product from agriculture (at 1960-61 prices) shows that the latter remained unaffected by the vicissitudes in the former. During the fifties and sixties, serious floods and crop damages were experienced in 1955, 1968 and 1969, but these had no effect on the net product from agriculture in the country. During the seventies, flood damage reported in 1971 set a new record while that of 1972 was the lowest. Compared to the preceding year, the net domestic product from agriculture in 1971-72 was marginally up by 1.1 per cent but showed a decline by 1.3 per cent in 1972-73 despite the significant improvement in the flood situation. It appears that the effect of floods on the overall agricultural production is almost negligible.

4.7.3. Amongst the five States considered for detailed analysis, continuous data relating to State domestic product from agriculture for a decade or more are available in respect of Uttar Pradesh, Bihar, West Bengal and Orissa. These are at current prices but for comparison, have been brought to 1960-61 base; the relevant data are given in Annexure 4.12. In West Bengal and Orissa, there is a close parallel movement in damages and production in most of the years, suggesting a positive correlation between floods and crop production.

4.7.4. Data relating to Bihar, which has reported the maximum order of damages in relation to crop production call for some comments. Crop damages were about 12 per cent of crop production in 1971-72 and 1974-75. In the first year there was a 4 per cent increase in crop production and in the second year an 8 per cent decrease as compared to the respective preceding years. Data for Uttar Pradesh do not indicate any definite relationship between flood damages and overall agricultural production. Considering all the four States, there is no evidence that a year of high crop damages due to floods has brought down agricultural production.

4.7.5. One reason for this is that in most of the States and in most of the years damage to crops from floods was less than 5 per cent of the overall crop production. It was even less (3 to 4 per cent) in Uttar Pradesh and Orissa. The percentage was higher for Bihar (12) only in 1971-72 and 1974-75 and West Bengal (8.5) in 1971-72. Such order of crop losses cannot be expected to have a marked effect on the overall trend for the State as a whole. It could also be argued that a year of severe flood would mean abundant rainfall practically all over the State, most of which would be outside the flood zone, and if the rains are fairly distributed during the crop season, the beneficial effects of this on crop production in non-flood areas would more than off-set flood losses and would result in higher crop production for the State as a whole.

4.7.6. But the situation could be different at the level of districts, tehsils or blocks actually affected by floods. Since data relating to blocks are not readily available, the analysis is limited to districts. For this purpose, a few districts in Uttar Pradesh and Bihar have been selected for the analysis.

4.7.7 In recent years large scale floods have occurred in Uttar Pradesh in 1978 and 1971 in that order. Since district-wise data are incomplete for 1978, the analysis is confined to 1971. In that year, a total of 52.6 lakh hectares were affected of which 26.5 lakh hectares were under cultivation. A number of districts, particularly in the eastern region of the State were affected. The more severely affected among them were Bahraich, Gonda, Basti, Sitapur, Barabanki and Varanasi which together accounted for 36 per cent of crop areas submerged in the State and an equal proportion of crop losses.

4.7.8. In Bihar, the maximum crop area affected in recent years was in 1974, hence that year has been selected for analysis. About 17.5 lakh hectares under crops were submerged which constituted 56 per cent of total area affected. Districts badly inundated in 1974 were Saran, Champaran, Darbhanga, Monghyr, Purnea and Muzaffarpur which accounted for over 90 per cent of both the crop area affected and the crop losses.

4.7.9. The main kharif crops grown in the selected districts are paddy, maize, bajra, jowar and some pulses. Paddy commands the largest area, followed by maize. The behaviour of area, production and yield of these crops in the selected districts under conditions of severe flood compared to the five years' average centred on the flood year itself has been examined, the five years selected are 1969-70 to 1973-74 in the case of Uttar Pradesh and 1972-73 to 1976-77 in the case of Bihar. It should be noted that the above average gives some weightage to the growth factor which might have been present. The relevant data are presented in Annexure 4.13.

4.7.10. Taking the six districts of Uttar Pradesh together, there was a 5 per cent decline in production of paddy and 7 per cent decline in yields in 1971, compared to the average during the quinquennium 1969-70 to 1973-74 although 36 to 94 per cent of the cropped area in these districts was affected by floods in that year. In the Bihar districts, the average yield of winter paddy, which is the major crop in the region, showed an increase of 2 per cent and production showed a nominal decline of 0.7 per cent in the flood year. The proportion of crop area affected in these districts too was much higher, viz., in the range of 34 to 62 per cent of the net sown area. Taking the districts separately, no definite relationship could be seen between the extent of area under paddy affected on the one hand and paddy yields and production on the other. The figures in Annexure 4.13. indicate that the extent of reduction in yields and in production of paddy in both regions were considerably low, compared to the proportion of crop area affected, in some districts there was no reduction at all. A possible reason for this could be that areas initially reported as partially affected by floods recovered subsequently with no tangible reduction in yield. This is not surprising as years of flood are associated with good rainfall which is favourable to paddy. Another reason could be that some of the crop areas completely damaged by floods were resown/replanted. A third possibility is that flood years being years of good rainfall, areas not affected by floods yield more than in normal years, thereby raising the overall level of average yield. Further, the loss of yields and production depend on the time occurrence of flood because the feasibility of post-flood resowing/replanting depends very much on the time factor. On the whole it appears that not much damage is done by floods to the paddy crop. The picture could have been clearer if data were available for groups of specific villages affected by floods.

4.7.11. Other major crops of kharif season grown in this region are maize, bajra and jowar. It was observed that these crops fared rather badly under conditions of flood. The decline in production observed in the selected districts of Uttar Pradesh was as much as 85 per cent in maize, and 65 per cent in the case of both jowar and bajra. In the Bihar districts production and yield of maize crop suffered by about 26 per cent in 1974-75 as compared to the reference period. The district-wise data convincingly show that production and yield of crops like maize, bajra and jowar were severely affected by floods.

4.7.12 Little attention has been paid to the long term impact of floods on the economy of the affected areas. The sense of insecurity caused by recurrence of floods dissuades farmers from making long-term investments. As a result, agriculture in flood prone areas continues to be backward with minimum possible investments. Even investments in roads, railways, bulidings, etc. become risky on account of the recurrence of flood. All these taken together result in low economic development. A joint study* conducted by the

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*Spatial Patterns of Levels and Growth of Agricultural output in India by G.S. Bhalla and Y.K. Alagh. Occasional paper No. 12, School of Social Sciences, JNU—1978.

Planning Commission and the Jawaharlal Nehru University on foodgrain growth at the district level in the country from 1962-63 to 1970—73 gives some interesting information in this regard. The annual rate of growth of agricultural output during the period was 1.94 per cent for the country as a whole. The rates recorded by most of the flood prone districts of eastern Uttar Pradesh were only in the range of 0.1 to 1.9 per cent. The districts falling in this category are Ballia, Bahraich, Gonda, Azamgarh, Barabanki, Jaunpur and Sitapur. There were, however, a few districts in the region which showed better performance despite being similarly placed; these are Deoria (2.25 per cent), Basti (2.66 per cent), Gorakhpur (2.69 per cent) and Gazipur (3.55 per cent). The worst performance in the region was that of Varanasi district which recorded a negative growth rate of 0.84 per cent. Compared to these, some of the well-irrigated and relatively flood-free districts of Uttar Pradesh having more or less similar agro-climatic conditions like Aligarh, Muzaffarnagar, Meerut, Bulandshahr, Unnao and Mathura recorded growth rates ranging from 4.41 to 6.47 per cent. Performance of north Bihar districts in most cases was as bad as of Varanasi. The rate of growth of foodgrain output in Darbhanga and Muzaffarpur was only 0.92 per cent each, whereas it was negative for Monghyr, Saharsa and Purnea—0.39 per cent for the first two and—2.29 per cent for Purnea. Exceptions in this regard in the region were Saran and Champaran districts which recorded more than 3 per cent growth. Flood prone districts of Orissa *viz.*, Balasore, Cuttack and Puri recorded negative rates of growth. The comparatively better performance of some of the flood prone districts like Deoria, Basti and Gorakhpur in Uttar Pradesh and Saran and Champaran in Bihar can be attributed to better irrigation facilities and the good performance of wheat crop which recorded sizable gains in area and productivity from 1966-67 onwards. Even then, their growth rates were not as high as those of similarly situated flood-free districts mentioned earlier. From the foregoing analysis it appears that flood is an inhibiting factor in the process of agricultural growth of areas subject to frequent flooding.

सत्यमेव जयते

ANNEXURE 4.1

Share of major States in flood damages (at current prices) in recent years

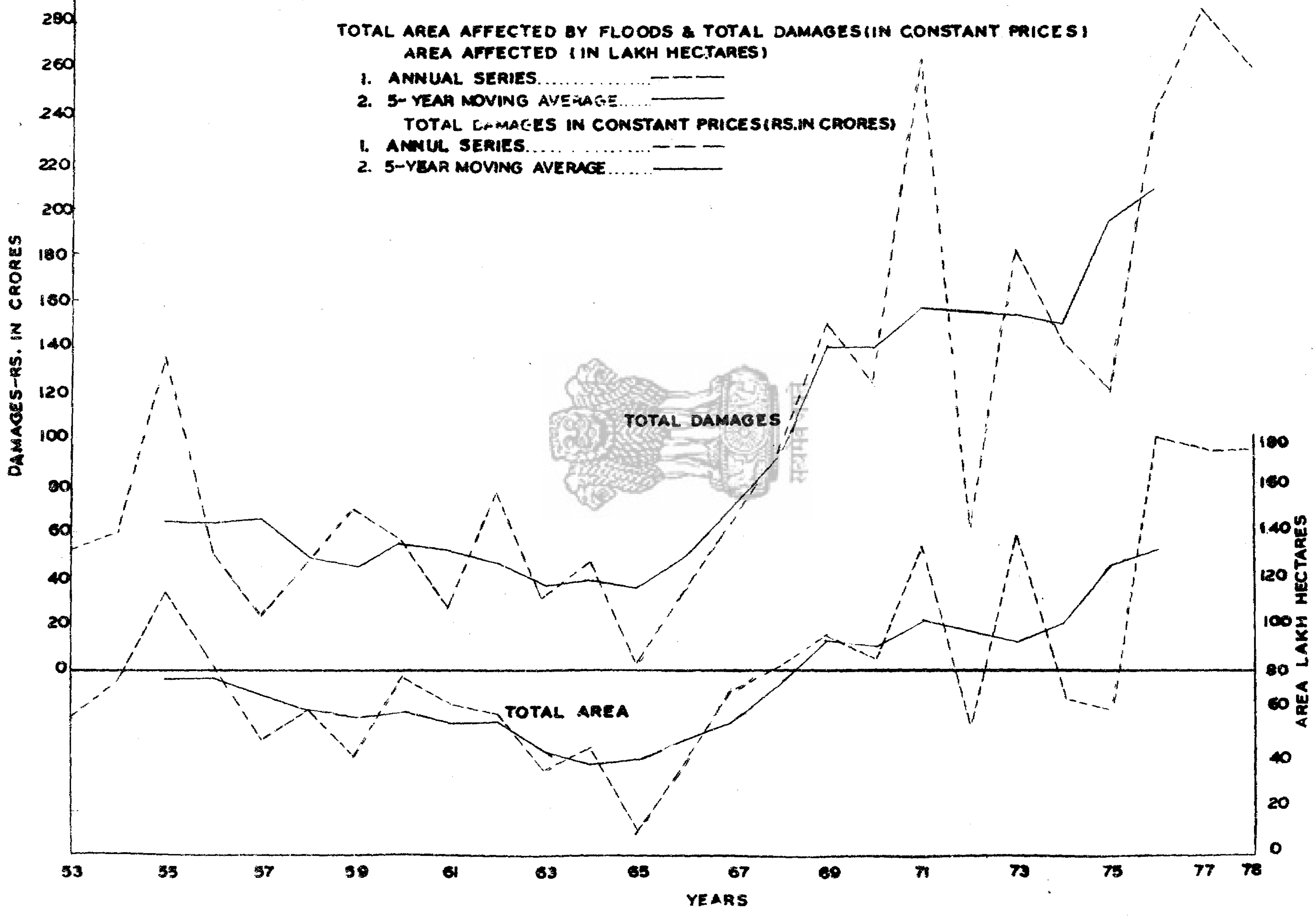
(in per cent) (Ref : Para 4.3.4)

	1971	1972	1973	1974	1975	1976	1977	1978	Average for 1971-78
Andhra Pradesh	..	12·0	(a)	(a)	(a)	23·9	50·8	(a)	15·4
Assam	(a)	15·3	2·9	3·4	(a)	1·4	2·6	(a)	2·1
Bihar	34·4	1·1	3·5	67·1	56·5	23·2	1·0	16·7	23·2
Gujarat	(a)	(a)	20·9	(a)	15·3	6·6	4·5	1·2	5·7
Haryana	1·0	(a)	(a)	..	(a)	4·3	5·9	5·3	3·2
Madhya Pradesh	(a)	(a)	12·2	(a)	(a)	(a)	..	..	1·3
Orissa	5·0	29·6	9·0	(a)	10·0	(a)	(a)	3·3	4·5
Punjab	(a)	(a)	1·4	(a)	2·1	5·6	(a)	(a)	1·4
Rajasthan	(a)	6·9	17·8	(a)	4·5	2·3	6·3	1·2	4·5
Tamil Nadu	..	17·3	4·7	..	..	(a)	12·7	..	3·8
Uttar Pradesh	27·6	2·4	14·4	18·5	8·3	27·8	8·1	56·0	23·8
West Bengal	25·2	9·5	7·8	4·7	(a)	2·4	3·3	17·1	7·0

(a) less than 1 per cent.

Source : Data furnished by the Central Water Commission.

CHART- I - ALL-INDIA



TOTAL AREA AFFECTED BY FLOODS & TOTAL DAMAGES(IN CONSTANT PRICES)

CHART II- ALL-INDIA

CROPED AREA AFFECTED & CROP DAMAGES (IN CONSTANT PRICES)

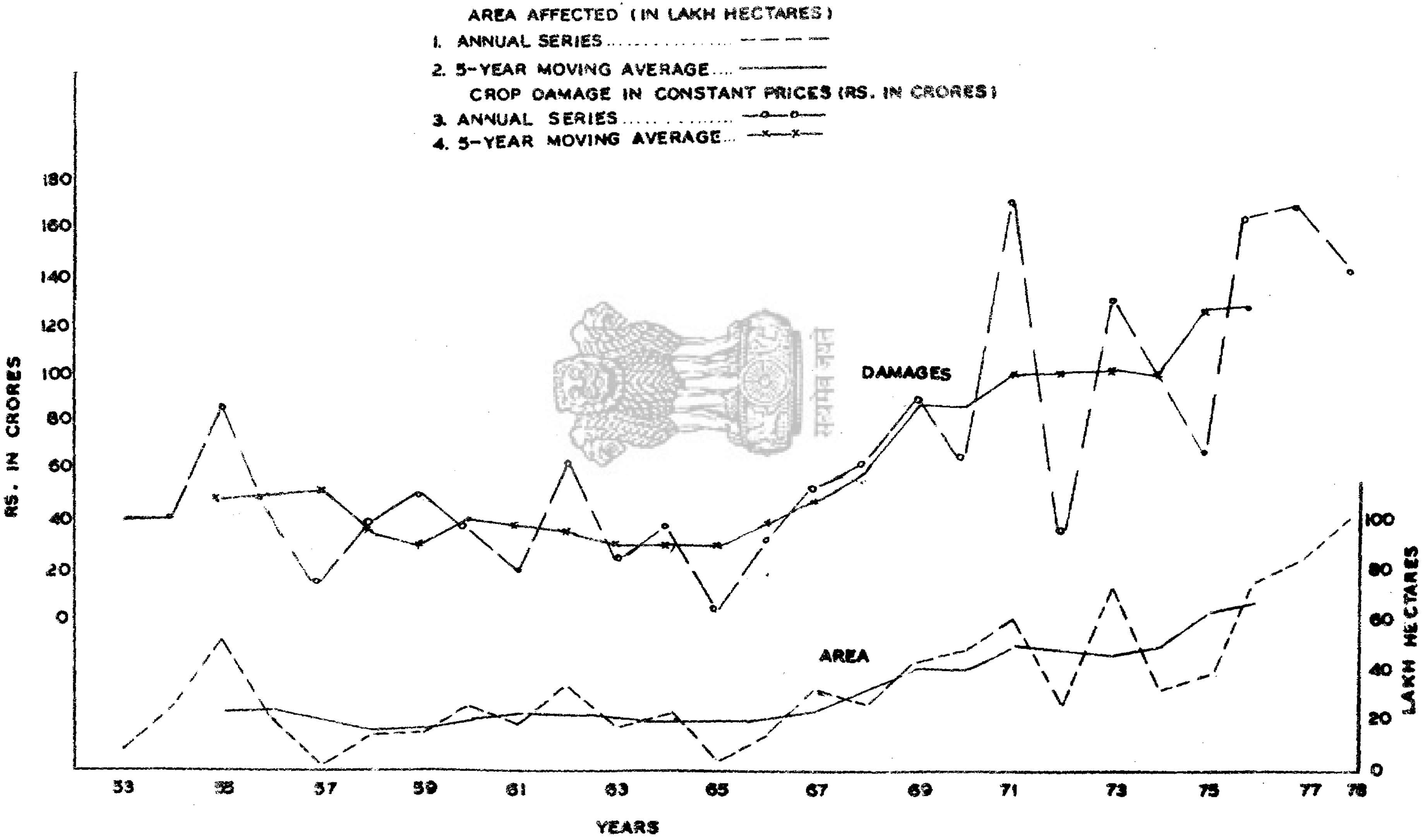


CHART - III - ALL INDIA

NON- CROP AREA AFFECTED AND DAMAGE TO PROPERTY etc. (IN CONSTANT PRICES)

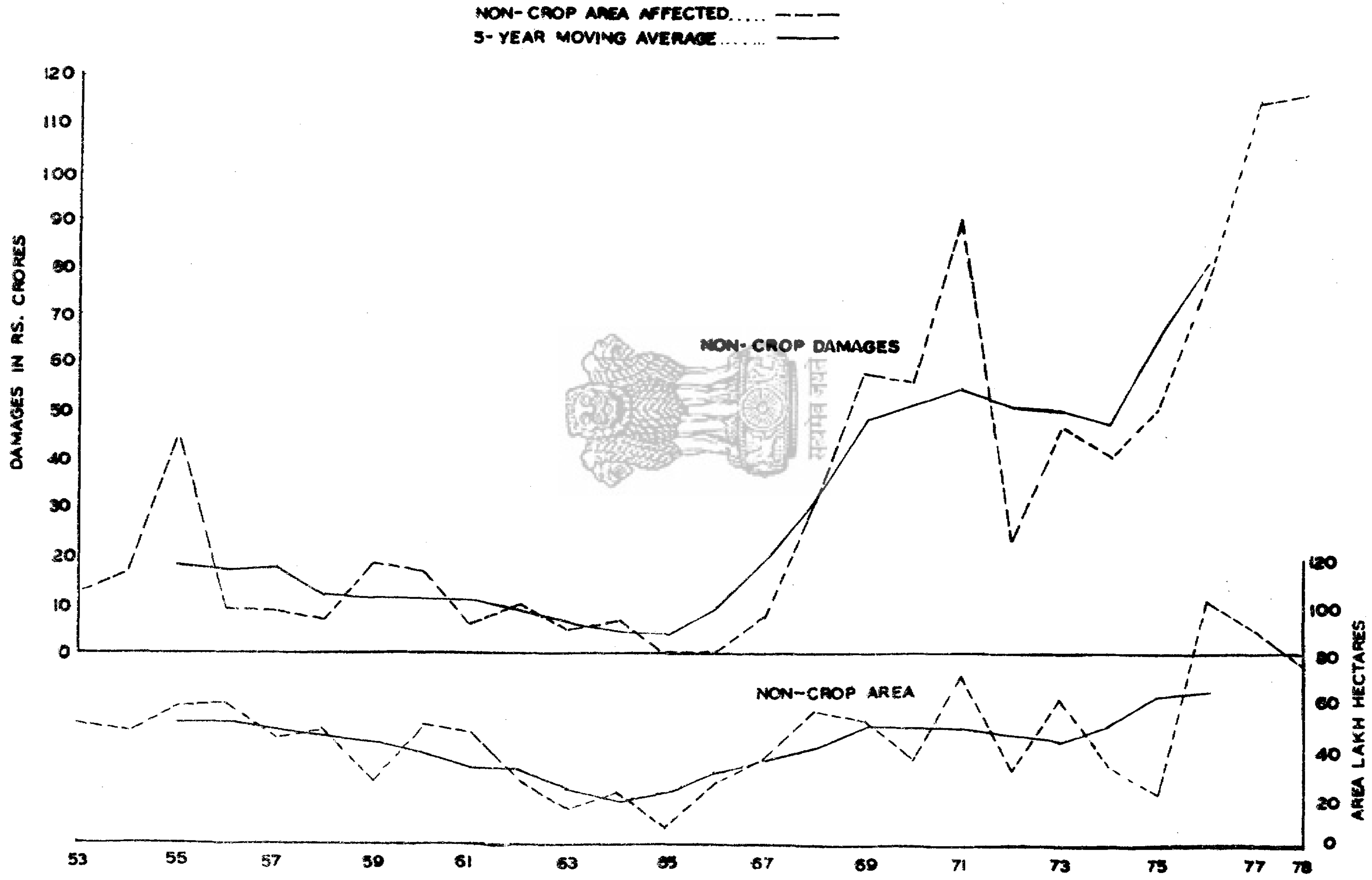


CHART - IV - ALL - INDIA

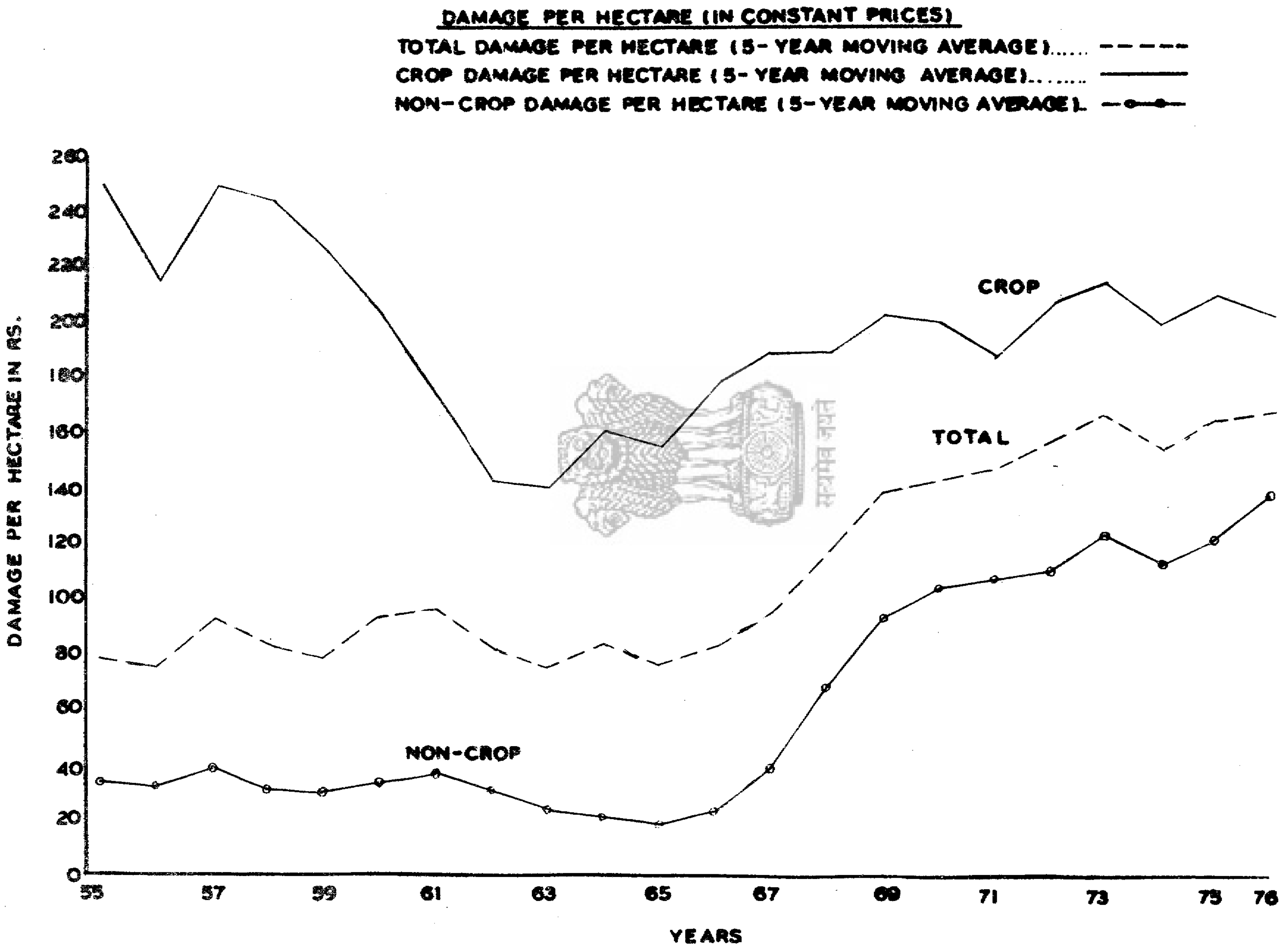
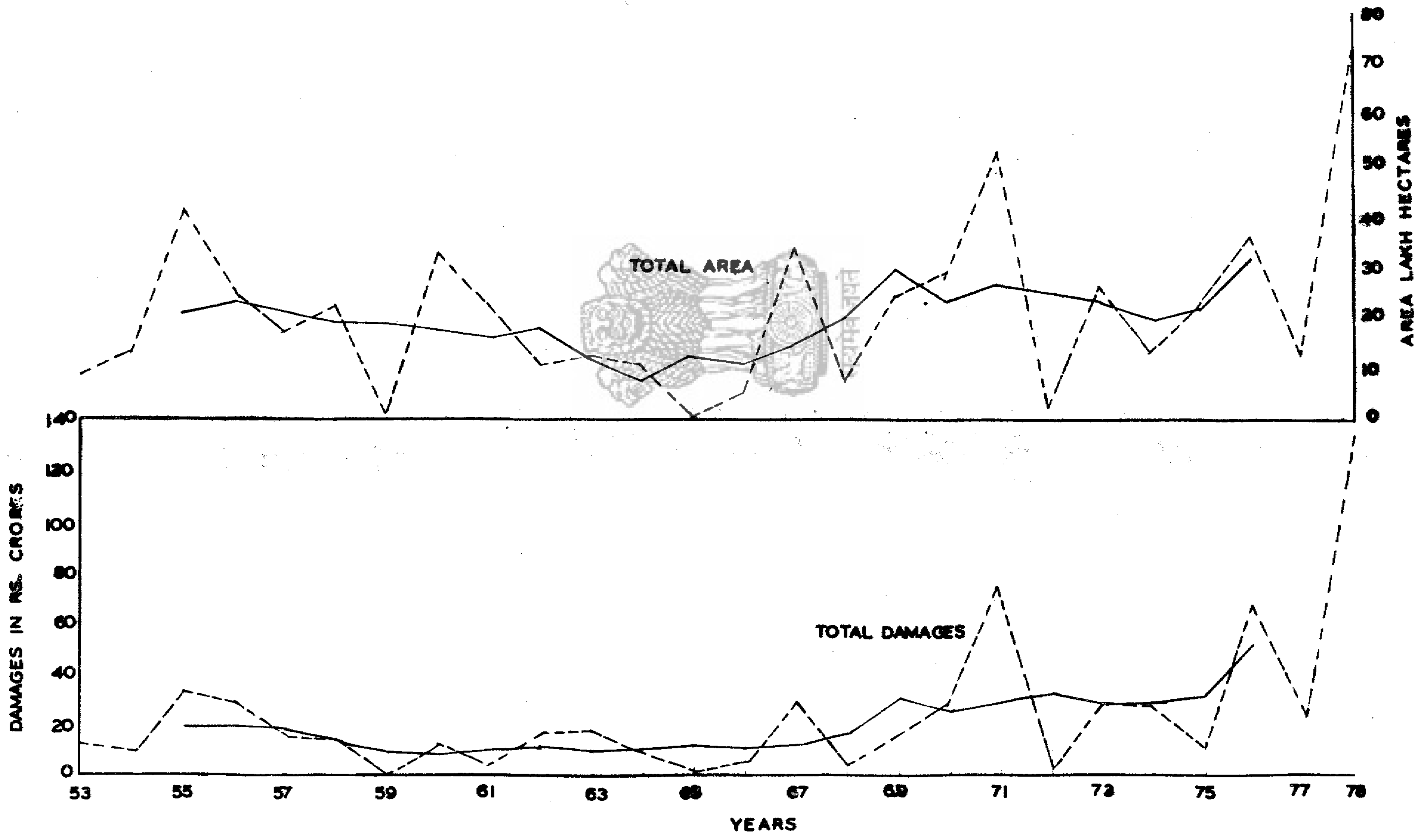


CHART - V - UTTAR PRADESH

TOTAL AREA AFFECTED BY FLOODS AND TOTAL DAMAGES (IN CONSTANT PRICES)

ANNUAL SERIES............... — — — —

5-YEAR MOVING AVERAGE...... ————



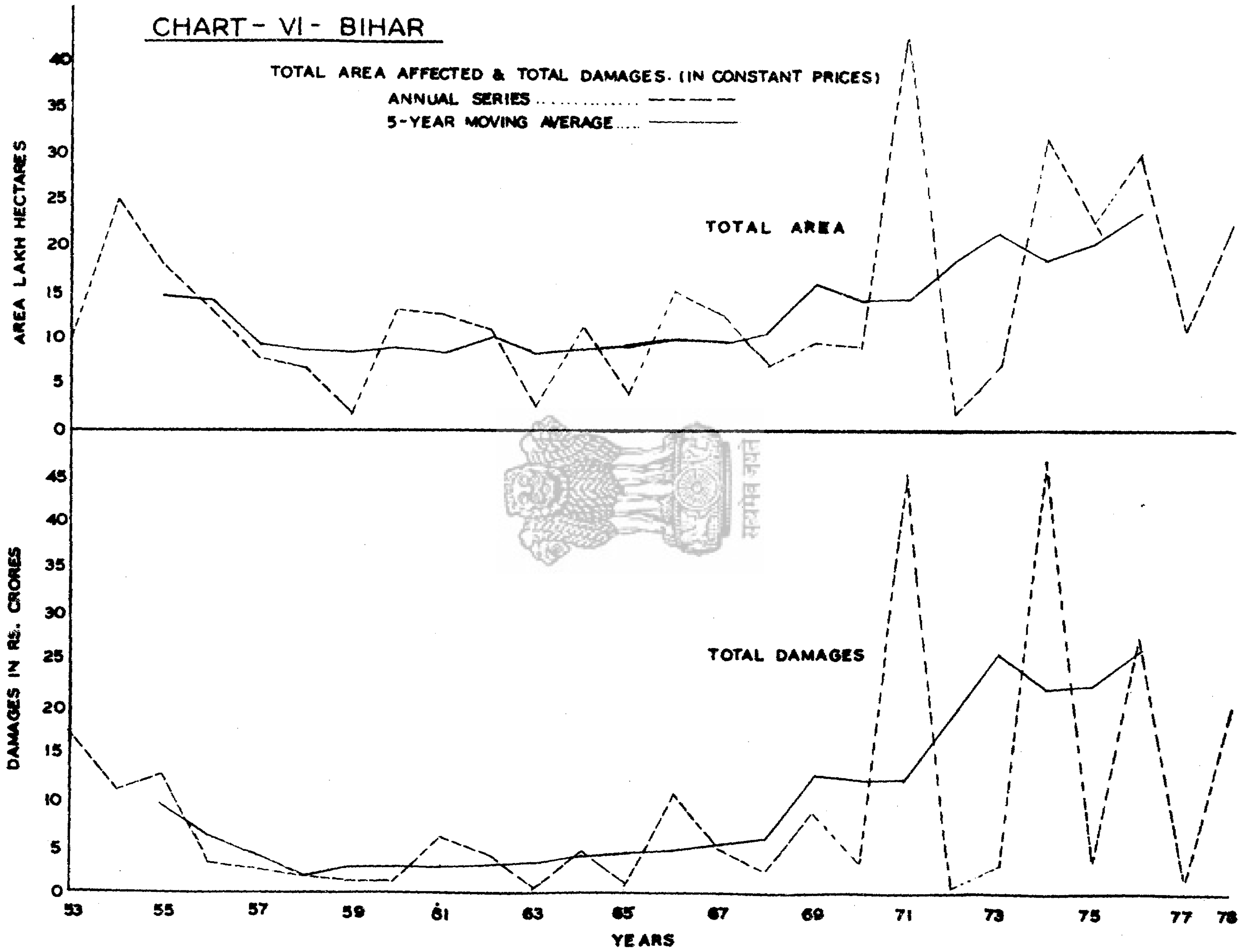
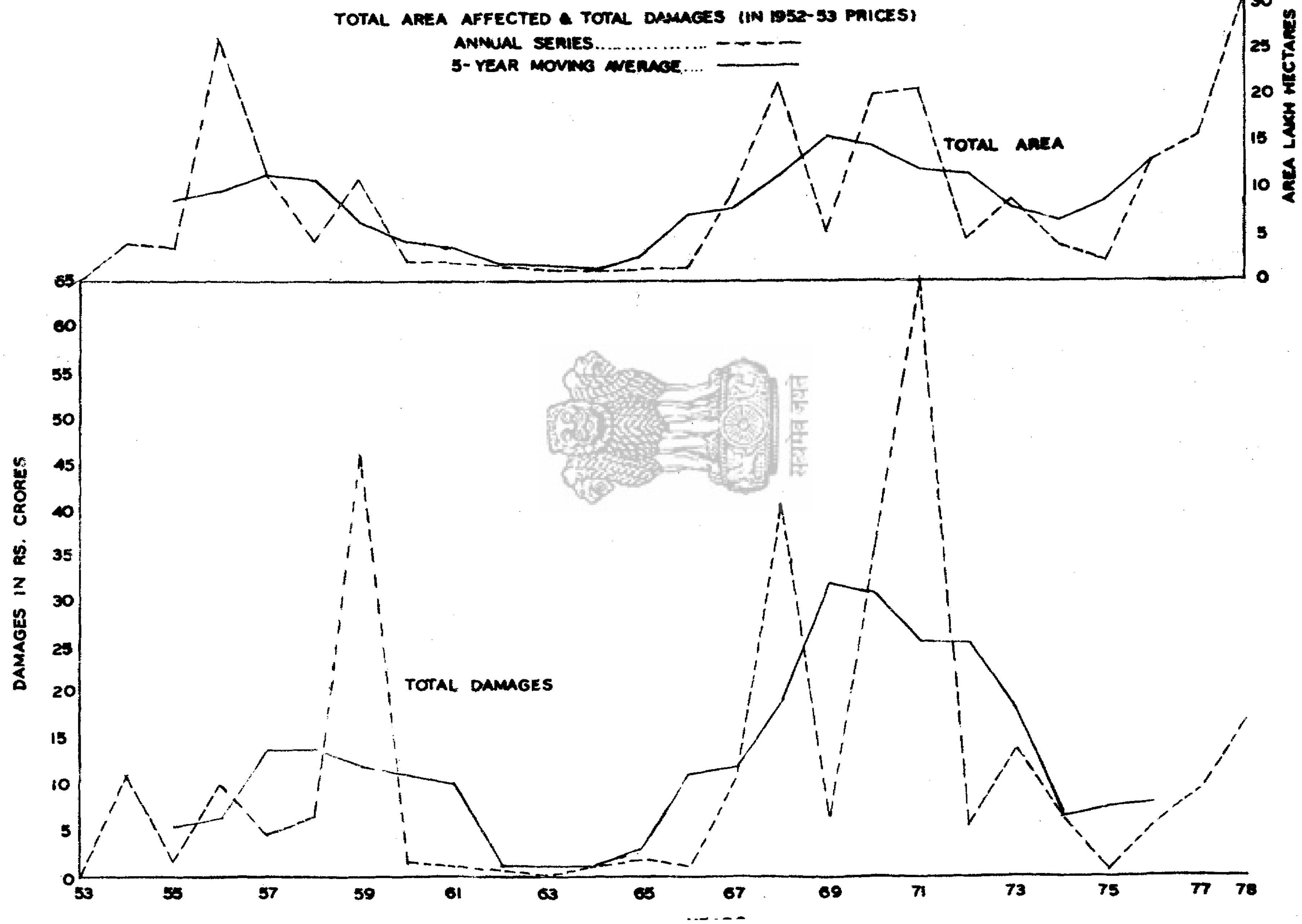


CHART- VI- BIHAR

CHART - VII - WEST BENGAL



TOTAL AREA AFFECTED & TOTAL DAMAGES (IN 1952-53 PRICES)

CHART - VIII - ORISSA

TOTAL AREA AFFECTED & TOTAL DAMAGES (IN CONSTANT PRICES)

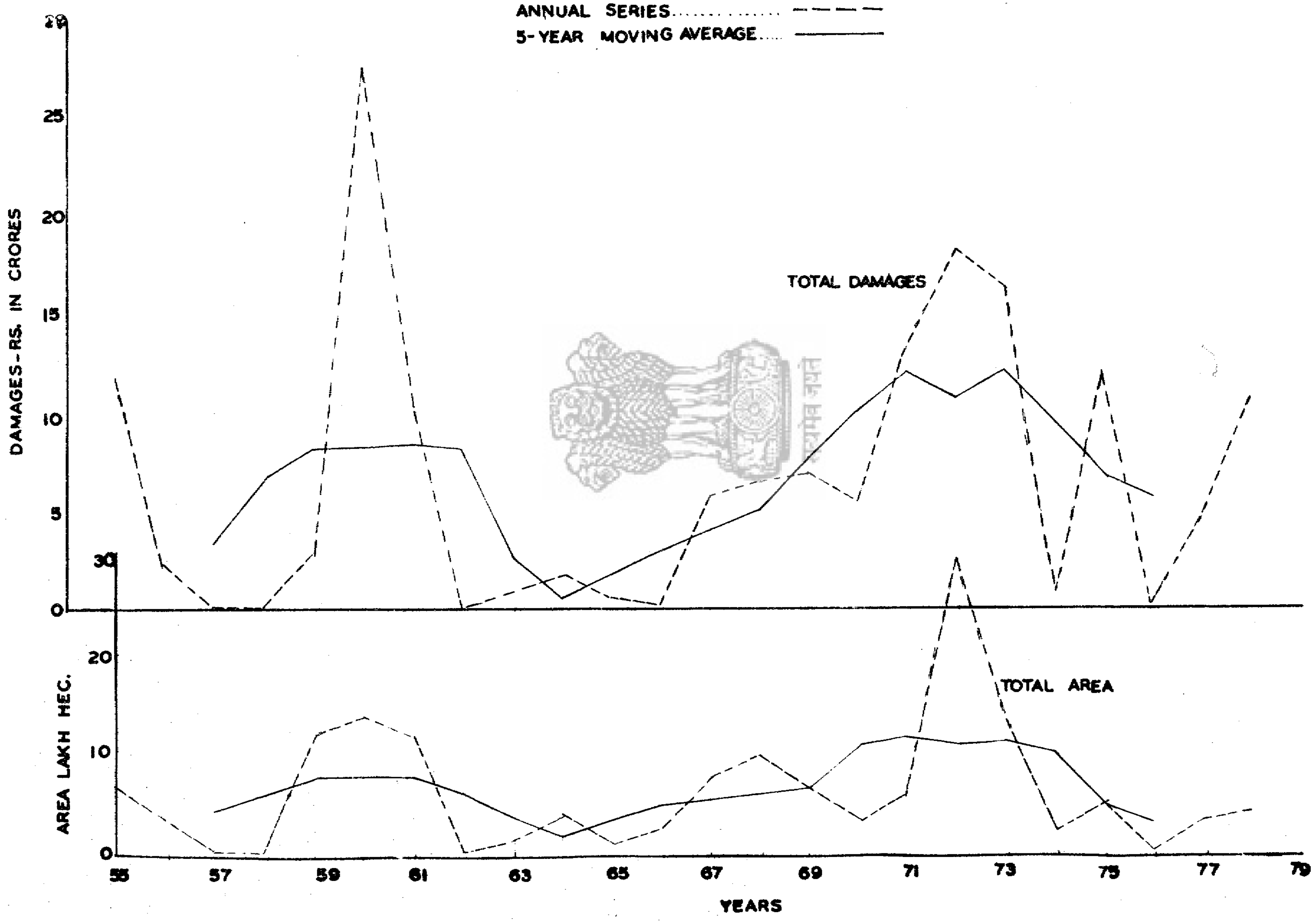
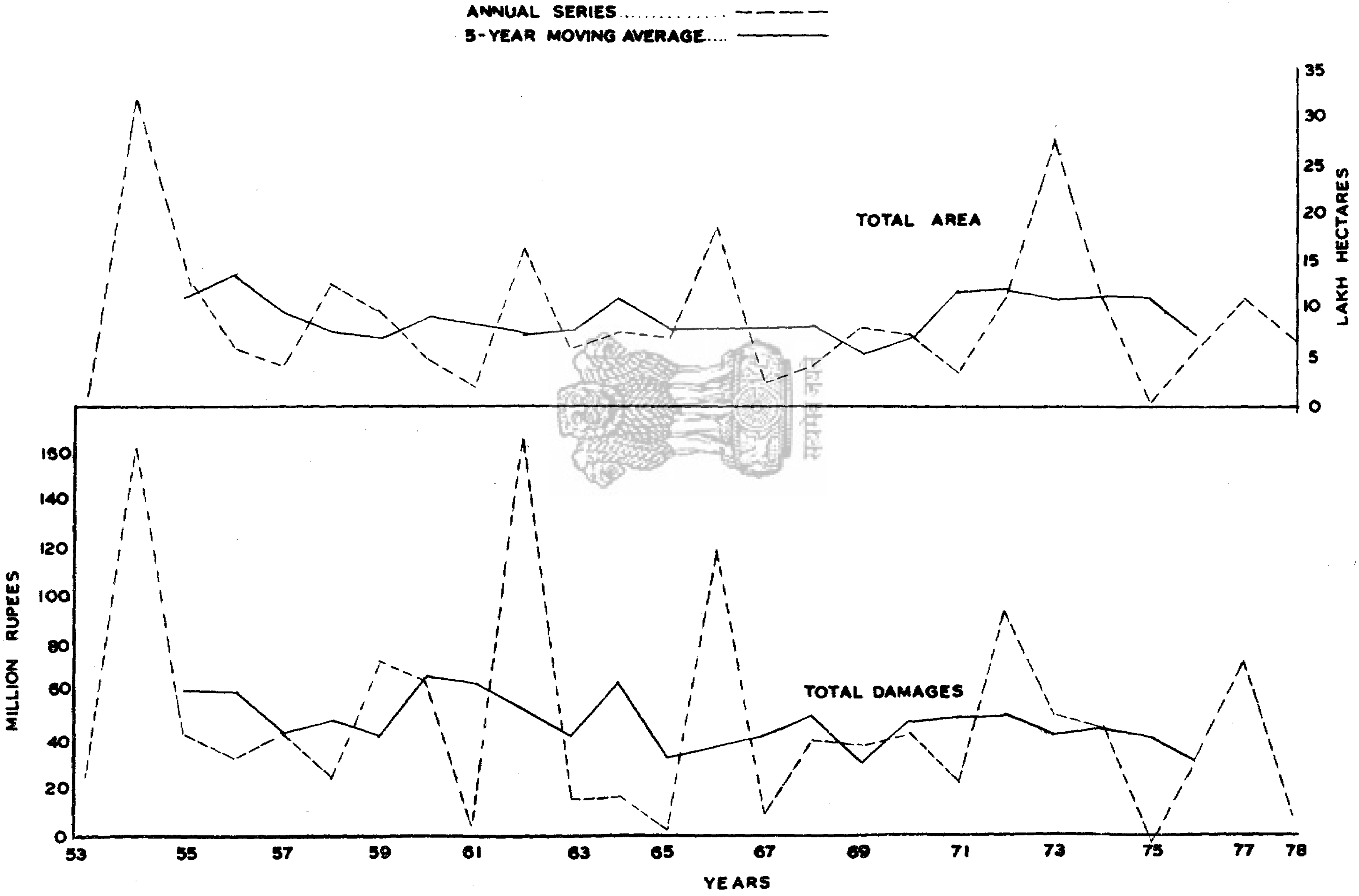


CHART - IX - ASSAM

TOTAL AREA AFFECTED & TOTAL DAMAGES (IN CONSTANT PRICES)



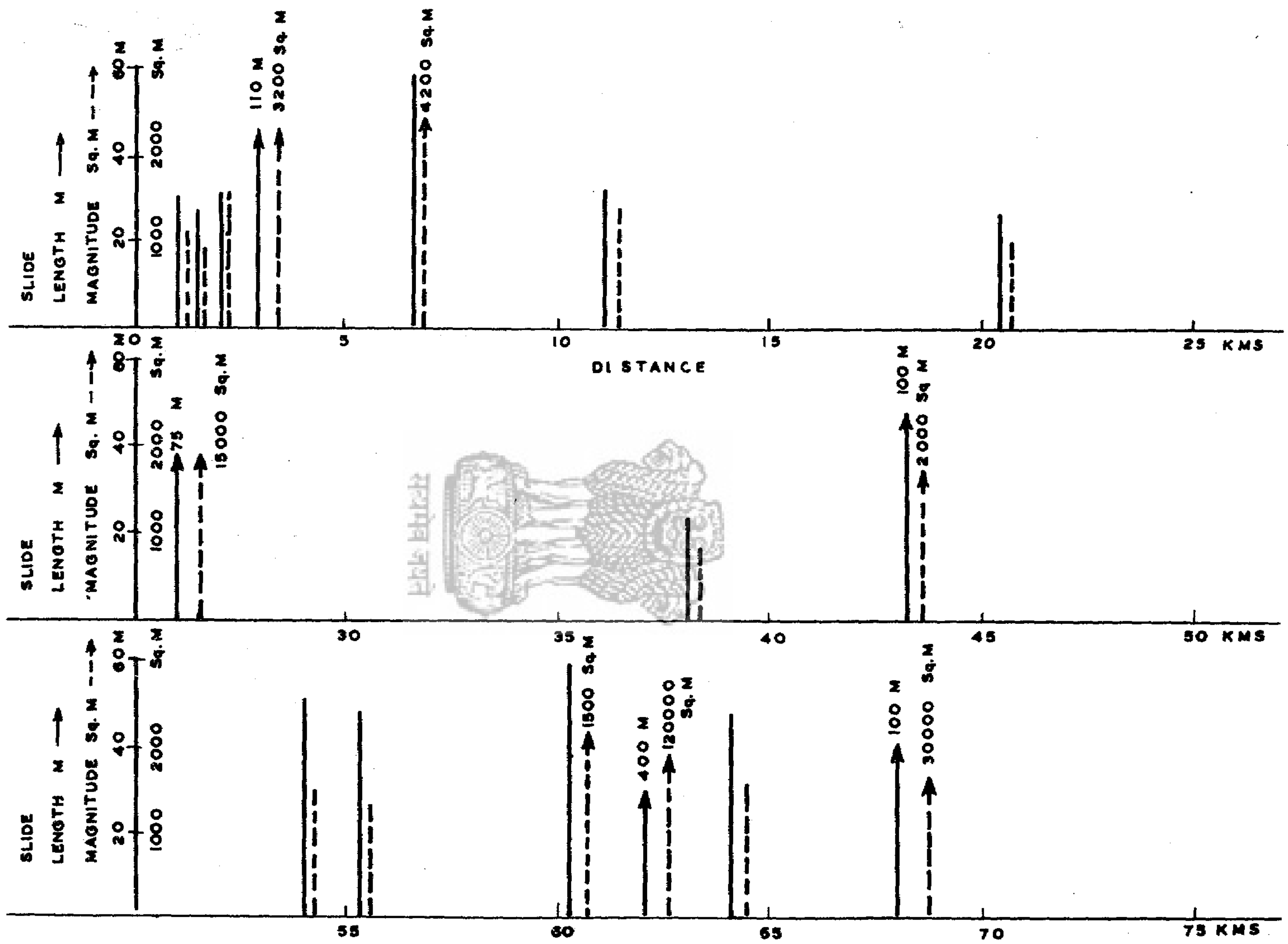


FIG. 11·27 DISTRIBUTION OF FREQUENCY AND MAGNITUDE OF LANDSLIDES ALONG ONE OF THE NATIONAL HIGHWAYS

DRG. NO. R.B.A/S/85/79

ANNEXURE 4.2

Area affected by floods in India

Ref. : Para 4·4·1

(in lakh hectares)

Year	Cropped area		Non-cropped area		Total area		Proportion of cropped area to total area as per cent	5-year moving average
	annual	5-year moving average	annual	5-year moving average	annual	5-year moving average		
1	2	3	4	5	6	7	8	9
1953	9·3		50·1		59·4		15·66	
1954	26·5		48·3		74·8		35·43	
1955	54·0	23·06	57·7	52·08	111·7	75·14	48·34	26·94
1956	21·0	24·18	59·1	51·56	80·1	75·74	26·22	28·58
1957	4·5	21·96	45·2	47·22	49·7	69·18	9·05	28·83
1958	14·9	16·46	47·5	45·64	62·4	62·10	23·88	26·11
1959	15·4	15·92	26·6	43·22	42·0	59·14	36·67	26·47
1960	26·5	22·14	49·8	39·30	76·3	61·44	34·73	36·29
1961	18·3	23·10	47·0	32·98	65·3	56·08	28·02	42·59
1962	35·6	24·96	25·6	31·96	61·2	56·92	58·17	45·94
1963	19·7	20·16	15·9	23·58	35·6	43·74	55·34	43·81
1964	24·7	19·72	21·5	19·42	46·2	39·14	53·46	45·81
1965	2·5	19·20	7·9	21·86	10·4	41·06	24·04	43·50
1966	16·1	20·64	26·2	29·80	42·3	50·44	38·06	38·96
1967	33·0	24·38	37·8	35·90	70·8	60·28	46·61	37·36
1968	26·9	33·58	55·6	41·52	82·5	75·10	32·61	44·03
1969	43·4	42·84	52·0	50·30	95·4	93·14	45·49	45·84
1970	48·5	41·12	36·0	49.30	84·5	90·42	57·40	45·05
1971	62·4	50·94	70·1	50·42	132·5	101·36	47·09	49·61
1972	24·4	48·86	32·8	46·82	57·2	95·68	42·66	50·36
1973	76·0	46·86	61·2	44·22	137·2	91·08	55·39	51·40
1974	33·0	49·74	34·0	50·62	67·0	100·36	49·25	50·57
1975	38·5	61·36	23·0	62·32	61·5	123·68	62·60	51·53
1976	76·8	66·26	102·1	64·86	178·9	131·12	42·93	51·98
1977	82·5		91·3		173·8		47·47	
1978	100·5		73·9		174·4		57·63	

Source **: Basic data furnished by Central Water Commission.**

ANNEXURE 4.3

Damage caused by floods in India at current and constant (1952-53) Prices

Ref : Para 4.5.1

(in lakh rupees).

Year	crop damage			non-crop damage			total damage		
	at current prices	at constant prices	5-year moving average of Col. 3	at current prices	at constant prices	5-year moving average of Col. 6	at current prices	at constant prices	5-year moving average of Col. 9
1	2	3	4	5	6	7	8	9	10
1953	4206·0	3990·51		1214·0	1148·53		5420·0	5139·04	
1954	4100·1	4209·55		1687·8	1694·58		5787·9	5904·13	
1955	7795·5	8950·06	4530·4	4074·0	4452.46	1814·41	11869·5	13402·52	6344·81
1956	4203·2	4161·58	4516·7	929·6	905·16	1728·03	5132·8	5066·74	6244·73
1957	1455·6	1340·33	4664·7	947·1	871·30	1760·77	2402·7	2211·63	6425·48
1958	4353·4	3921·98	3631·6	795·5	716·67	1217·07	5148·9	4638·65	4848·64
1959	5721·7	4949·57	3201·3	2146·3	1858·27	1152·27	7868·0	6807·84	4353·54
1960	4613·2	3784·41	4237·6	2131·0	1733·93	1174·64	6744·2	5518·34	5412·27
1961	2494·5	2010·7	3945·9	731·1	581·16	1134·66	3225·6	2591·23	5080·57
1962	8028·7	6522·10	3718·6	1250·6	983·18	900·05	9279·3	7505·28	4618·68
1963	3123·6	2463·41	3027·5	684·7	516·75	555·73	3808·3	2980·16	3583·21
1964	5708·3	3813·16	3300·3	1016·2	685·23	452·38	6724·5	4498·39	3752·66
1965	541·3	328·66	3077·3	19·9	12·34	418·51	561·2	341·00	3495·78
1966	6404·0	3374·08	3860·6	118·0	64·41	941·56	6522·0	3438·49	4802·11
1967	11955·0	5407·06	4910·8	1722·0	813·80	1962·61	13677·0	6220·86	6873·40
1968	13710·1	6379·76	6148·2	6561·6	3132·03	3075·57	20271·7	9511·79	9223·74
1969	21101·9	9064·39	8924·8	12229·5	5790·48	4861·26	33331·4	14854·87	13786·05
1970	16178·1	6515·55	8602·1	12503·9	5677·12	5173·48	28682·0	12092·67	13775·58
1971	42262·8	17257·17	9968·3	20935·4	8992·87	5489·37	63198·2	26250·04	15457·67
1972	9855·8	3793·61	10126·4	5963·4	2374·91	5158·96	15819·2	6168·52	15285·32
1973	42803·0	13210·80	10160·1	14106·1	4711·46	5078·10	56909·1	17922·26	15238·25
1974	41163·1	9854·70	9925·3	15734·3	4138·43	4839·16	56897·4	13993·13	14764·49
1975	27118·8	6684·45	12514·1	20008·6	5172·85	6649·85	47127·4	11857·30	19163·94
1976	59507·5	16083·11	12714·9	29367·8	7798·14	8027·88	88875·3	23881·25	20742·81
1977	71937·3	16737·39		48010·6	11428·37		119947·9	28165·76	
1978	60499·0	14214·99		48622·3	11601·60		109121·3	25816·59	

Source : Basic data furnished by Central Water Commission.

ANNEXURE 4.4

Flood Damage per hectare of area affected—All-India (1952-53) price

(Rupees per hectare)

Ref : para 4·5·8

year	crop damage per hectare		non-crop damage per hectare		total damage	
	annual	5-year moving average	annual	5-year moving average	annual	5-year moving average
1	2	3	4	5	6	7
1953	429·09		22·92		86·52	
1954	158·85		35·08		78·93	
1955	165·74	294·94	77·17	33·95	119·99	78·64
1956	198·17	216·77	15·32	32·39	63·26	76·20
1957	297·85	249·28	19·28	39·34	44·50	92·84
1958	263·22	244·69	15·09	30·87	74·34	83·30
1959	321·40	227·02	69·86	30·28	162·09	78·59
1960	142·81	204·10	34·82	34·11	72·32	94·21
1961	109·84	176·46	12·37	37·59	39·68	96·09
1962	183·21	143·06	38·41	29·99	122·64	83·14
1963	125·05	140·79	32·50	23·34	83·71	75·24
1964	154·38	160·73	31·87	21·36	97·37	83·56
1965	131·46	156·86	1·56	17·98	32·79	76·61
1966	209·57	179·29	2·46	22·75	81·29	82·92
1967	163·85	190·18	21·53	38·65	87·87	94·59
1968	237·17	190·76	56·33	69·32	115·29	116·65
1969	208·85	204·16	111·36	94·49	155·71	140·02
1970	134·34	202·48	154·92	104·66	143·11	144·01
1971	276·56	189·81	128·29	108·79	198·11	147·08
1972	155·48	207·77	72·41	110·86	107·84	157·71
1973	173·83	215·62	76·98	124·86	130·63	167·65
1974	298·63	202·20	121·72	114·48	208·85	154·72
1975	173·62	211·68	224·91	125·03	192·80	165·57
1976	209·42	205·20	76·38	141·03	133·49	169·05
1977	202·88		125·17		162·06	
1978	141·44		156·99		148·03	

Data derived from Annexures 4·2 and 4·3

ANNEXURE 4.5

Summary statement of major trends in area affected and damage in major States

(area in lakh hects.)
damages in lakh Rupees (constant prices) ;
(unit area damages in Rupees per hectare)

Ref : para 4·6·1

	Uttar Pradesh	Bihar	West Bengal	Orissa	Assam	all-India
	1	2	3	4	5	6
total area affected						
1953-65	17·44	10·61	5·39	4·90	10·13	59·62
1966-70	20·12	10·82	11·56	5·92	7·96	75·10
1971-75	23·46	21·32	7·90	11·24	10·68	91·08
1976-78	40·90	21·26	19·50	2·40	7·83	175·70
cropped area affected						
1953-65	7·93	5·08	1·25	1·91	1·33	20·99
1966-70	10·42	5·86	4·94	2·50	1·80	33·58
1971-75	13·22	9·66	3·78	5·86	2·10	46·86
1976-78	22·33	6·73	6·13	1·73	4·13	86·60
non-cropped area affected						
1953-65	9·51	5·53	4·14	2·99	8·80	38·63
1966-70	9·70	4·96	6·62	3·42	6·16	41·52
1971-75	10·24	11·66	4·12	5·38	8·58	44·22
1976-78	18·57	14·53	13·37	0·67	3·70	89·10
total damages						
1953-65	1270·58	1003·16	661·95	526·60	536·14	5123·45
1966-70	1637·22	1147·15	1897·81	490·51	499·20	9223·74
1971-75	2728·05	5154·66	1859·58	1206·16	429·22	15238·25
1976-78	7388·65	3248·21	1072·62	510·35	382·82	25954·54
crop damages						
1953-65	1055·56	847·27	486·27	393·96	418·84	3880·41
1966-70	1296·27	1046·42	1252·01	355·20	439·76	6148·17
1971-75	1748·37	3394·82	1450·56	745·71	400·96	10160·15
1976-78	5249·20	1612·34	537·75	146·22	314·50	15678·50

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	1	2	3	4	5	6
non-crop damages						
1953-65	215·02	155·89	175·68	132·64	117·30	1243·04
1966-70	340·95	100·73	645·80	135·31	59·44	3075·57
1971-75	979·68	1759·84	409·02	460·45	28·26	5078·10
1976-78	2139·45	1635·87	534·87	364·13	68·32	10276·04
unit area damage						
(i) all areas						
1953-65	72·85	94·55	122·81	107·47	52·93	85·94
1966-70	81·37	106·02	164·17	82·86	62·71	122·82
1971-75	116·29	241·78	235·39	107·31	40·19	167·31
1976-78	180·65	152·78	55·01	212·65	48·89	147·72
(ii) crop area						
1953-65	133·11	166·79	389·02	206·26	314·92	184·87
1966-70	124·40	178·57	253·44	142·08	244·31	183·09
1971-75	132·25	351·43	383·75	127·25	190·93	216·82
1976-78	235·07	239·58	87·72	84·52	76·15	181·05
(iii) non-crop area						
1953-65	22·61	28·19	42·43	44·36	13·33	32·18
1966-70	33·15	20·31	97·55	39·56	9·65	74·07
1971-75	95·67	150·93	99·28	85·59	3·29	114·84
1976-78	115·21	112·59	40·01	543·48	18·46	115·33

Source : Basic data furnished by Central Water Commission.

ANNEXURE 4.6

UTTAR PRADESH : *Trend in area affected by Floods and damages*

A : Area affected (lakh hectares)

Ref. : para 4.6.2

Year	crop area		non-crop area		total area	
	annual	5 year moving average	annual	5 year moving average	annual	5 year moving average
1	2	3	4	5	6	7
1953	NA	..	NA	..	9.1	..
1954	7.4	..	6.1	..	13.5	..
1955	25.7	..	15.6	..	41.3	21.2
1956	9.3*	11.4	15.7*	12.4	25.0	23.7
1957	6.3*	9.9	10.7*	11.3	17.0	21.2
1958	8.1*	5.9	13.7*	13.5	21.8	19.4
1959	Neg.	4.5	0.7	14.5	0.7	19.0
1960	5.9	5.4	26.6	12.3	32.5	17.7
1961	2.2	6.1	20.7	9.7	22.9	15.9
1962	10.6	7.7	Nil	10.2	10.6	17.8
1963	12.0	6.5	0.6	5.0	12.6	11.5
1964	7.7	6.6	2.9	1.3	10.6	8.0
1965	Neg.	7.5	0.8	5.2	0.8	12.7
1966	2.8	5.9	2.4	5.8	5.2	11.8
1967	15.2	7.0	19.1	7.4	34.3	14.5
1968	4.0	10.4	4.0	9.7	8.0	20.1
1969	13.1	15.2	10.9	14.4	24.0	29.6
1970	17.0	12.5	12.1	10.9	29.1	23.4
1971	26.5	14.7	26.1	12.3	52.6	27.0
1972	1.8	13.9	1.3	11.1	3.1	24.9
1973	15.0	13.2	11.3	10.2	26.3	23.5
1974	9.0	12.2	4.5	8.0	13.5	20.2
1975	13.8	13.1	8.0	9.1	21.8	22.2
1976	21.6	16.0	14.7	13.6	36.3	31.6
1977	6.1	..	6.9	..	13.0	..
1978	39.3	..	34.1	..	73.4	..

सत्यमेव जयते

* Figure estimated.
NA=Not available.
Neg= Negligible.

Source : Basic data furnished by Central Water Commission.

ANNEXURE 4.6—(*contd.*)

B : Damages at constant (1952-53) prices
(Rs. in lakhs)

year	crop damage		non-crop damage		total damage	
	annual	5 year moving average	annual	5 year moving average	annual	5 year moving average
1	2	3	4	5	6	7
1953	1026.57	..	199.62	..	1226.19	..
1954	700.21	..	169.68	..	869.89	..
1955	3028.70	1572.94	319.13	372.38	3347.83	1945.32
1956	2126.73	1586.55	691.33	366.03	2818.06	1952.57
1957	982.50	1446.50	482.15*	332.33	1464.65	1778.84
1958	1094.59	985.96	167.84*	343.72	1262.43	1329.69
1959	Neg.	613.80	1.21*	210.18	1.21	823.98
1960	726.00*	731.69	376.08*	133.80	1102.08	865.49
1961	265.91*	801.51	23.61*	148.48	289.52	950.00
1962	1571.97	951.25	100.24	152.61	1672.21	1103.87
1963	1443.69	807.39	241.28	77.64	1684.97	885.03
1964	748.70	827.01	21.85	82.53	770.55	909.54
1965	6.68	1015.11	1.24	119.72	7.92	1134.83
1966	364.01	803.73	48.03*	76.44	412.04	880.17
1967	2512.48	951.25	286.20	108.55	2798.68	1059.80
1968	386.78	1296.27	24.87	340.95	411.65	1637.22
1969	1486.30	2106.44	182.39	901.42	1668.69	3007.86
1970	1731.78	1625.82	1163.25	865.87	2895.03	2491.69
1971	4414.86	1964.85	2850.39	956.14	7265.25	2920.99
1972	109.39	1942.99	108.44*	1171.03	217.83	3114.01
1973	2081.91	1748.37	476.22	979.68	2558.13	2728.05
1974	1376.99	1870.80	1256.84	734.51	2633.83	2605.31
1975	758.69	2197.92	206.51	815.65	965.20	3013.58
1976	5027.03	3576.65	1624.54	1576.34	6651.57	5152.99
1977	1745.00		514.16	..	2259.16	..
1978	8975.56		4279.65	..	13255.21	..

* Estimated.
Neg=Negligible.

ANNEXURE 4.6—(*concluded*)

C : Damage per unit area (rupees per hectare)

year	crop damage		non-crop damage		total damage	
	annual	5 year moving average	annual	5 year moving average	annual	5 year moving average
1	2	3	4	5	6	7
1953	..	..	..	..	134·75	..
1954	94·62	..	27·82	..	64·44	..
1955	117·85	..	20·46	..	81·06	95·83
1956	228·68	146·45	44·03	29·92	112·72	80·46
1957	155·95	127·52	45·06	24·71	86·16	67·92
1958	135·13	128·56	12·25	23·44	57·91	58·49
1959	Neg	107·00	1·73	14·86	1·73	38·47
1960	123·05	105·47	14·14	5·85	33·91	52·79
1961	120·87	102·51	1·14	83·83	12·64	67·95
1962	148·30	121·95	Neg	84·99	157·76	82·15
1963	120·31	97·34	402·13	82·47	133·73	77·34
1964	97·23	99·17	7·53	86·24	72·69	90·66
1965	Neg	102·57	1·55	89·24	9·90	75·43
1966	130·00	97·84	20·01	10·06	79·24	58·98
1967	165·29	101·09	14·98	11·90	81·59	58·34
1968	96·70	121·46	6·22	30·82	51·46	76·26
1969	113·46	128·78	16·73	48·66	69·53	88·04
1970	101·87	187·88	96·14	62·34	99·49	85·77
1971	166·60	116·30	109·21	69·53	138·12	94·94
1972	60·77	124·21	83·42	172·04	70·27	120·05
1973	138·79	114·83	42·14	107·98	97·27	109·01
1974	153·00	128·05	279·30	108·24	195·10	118·03
1975	54·98	173·11	25·81	106·46	44·28	138·73
1976	232·73	191·03	110·51	123·13	183·24	155·40
1977	286·07	..	74·52	..	173·78	..
1978	228·39	..	125·50	..	180·59	..

Neg=Negligible.

सत्यमेव जयते

ANNEXURE 4·7

Bihar : Trends in area affected by floods and damages

A: Area affected (lakh hectares)

Ref. : Para 4·6·7

year	crop area*		non-crop area		total area	
	annual	5 year moving average	annual	5 year moving average	annual	5 year moving average
1	2	3	4	5	6	7
1953	9·3	..	0·4	..	9·7	..
1954	15·9	..	9·1	..	25·0	..
1955	10·1	8·5	7·6	6·2	17·7	14·7
1956	4·0	7·2	9·2	7·0	13·2	14·2
1957	3·0	4·3	4·9	5·3	7·9	9·6
1958	2·9	2·6	4·2	6·1	7·1	8·7
1959	1·5	2·7	0·6	5·9	2·1	8·6
1960	1·7	3·5	11·5	5·8	13·2	9·2
1961	4·5	2·9	8·2	5·5	12·7	8·4
1962	6·7	3·6	4·4	6·5	11·1	10·2
1963	Neg	3·5	2·7	4·9	2·7	8·4
1964	5·3	4·9	5·9	4·1	11·2	8·9
1965	1·1	5·0	3·2	4·2	4·3	9·2
1966	11·2	5·4	4·1	4·8	15·3	10·1
1967	7·3	5·3	5·2	4·5	12·5	9·8
1968	1·9	5·9	5·4	5·0	7·3	10·8
1969	5·1	6·7	4·6	9·6	9·7	16·3
1970	3·8	5·3	5·5	8·9	9·3	14·2
1971	15·5	5·6	27·1	8·6	42·6	14·2
1972	0·2	8·1	2·0	10·5	2·2	18·6
1973	3·5	9·7	3·8	11·6	7·3	21·3
1974	17·5	8·3	13·9	10·5	31·4	18·8
1975	11·7	8·7	11·4	11·9	23·1	20·6
1976	8·5	9·9	21·4	13·8	29·9	23·7
1977	2·3	..	9·2	..	11·5	..
1978	9·4	..	13·0	..	22·4	..

Neg = Negligible.

* = Estimated.

Souces : Basic data furnished by Central Water Commission.

ANNEXURE 4·7—(*contd.*)

B : Damages at constant prices (1952—53) prices

(In lakh rupees)

year	crop damage		non-crop damage		total damage	
	annual	5 year moving average	annual	5 year moving average	annual	5 year moving average
1	2	3	4	5	6	7
1953	2751·42	..	709·56	..	3460·98	..
1954	1540·04	..	652·61	..	2192·65	..
1955	2330·65	1512·10	144·81	329·84	2475·46	1841·94
1956	516·83	1019·44	93·28*	192·14	610·11	1211·58
1957	421·55*	751·03	48·94*	62·02	470·49	813·05
1958	288·11	327·46	21·08*	37·21	309·19	364·67
1959	198·01*	437·63	1·99*	36·68	200·00	474·31
1960	212·80*	508·81	20·75*	35·71	233·55	544·51
1961	1067·69	463·14	90·62*	34·78	1158·31	497·92
1962	777·42	571·67	44·10	63·85	821·52	635·53
1963	59·78	551·02	16·45*	66·72	76·23	617·74
1964	740·68	748·44	147·34	54·35	888·02	802·79
1965	109·53	767·90	35·09*	48·65	144·62	816·55
1966	2054·79	850·31	28·77*	45·55	2083·56	895·86
1967	874·72	949·60	15·60	104·75	890·32	1054·35
1968	471·85	1046·42	0·95	100·73	472·80	1147·16
1969	1237·11	1810·74	443·32*	726·65	1680·43	2537·38
1970	593·64	1648·26	15·03	724·18	608·67	2372·44
1971	5876·36	1675·54	3158·33	726·36	9034·69	2401·90
1972	62·36	2840·37	3·27	1094·75	65·63	3935·12
1973	608·21	3394·82	11·86	1759·84	620·07	5154·66
1974	7061·29	2731·11	2285·27	1719·55	9346·56	4450·65
1975	3365·86	2773·49	3340·49	1721·26	6706·35	4494·75
1976	2257·81	3052·83	2956·85	2106·68	5514·66	5159·51
1977	274·27	..	11·85	..	286·12	..
1978	2004·93	..	1938·92	..	3943·85	..

*=Estimated.

ANNEXURE 4·7—(*concluded*)

C : Damage per unit area (rupees per hectare)

year	crop damage		Non-crop damage		total damage	
	Annual	5 year moving average	annual	5 year moving average	annual	5 year moving average
1	2	3	4	5	6	7
1953	295·85	..	1773·90	..	356·80	..
1954	96·86	..	71·72	..	87·71	..
1955	230·76	178 64	19·05	376·96	139·86	138·03
1956	129·21	139·34	10·14	23·18	46·22	75·88
1957	140·52	146·37	9·99	9·50	59·56	76·89
1958	99·35	125·25	5·02	6·05	43·55	52·45
1959	132·01	146·86	3·32	6·24	95·24	61·45
1960	125·18	141·97	1·80	6·24	17·69	64·34
1961	237·26	122·10	11·05	6·45	91·21	61·28
1962	116·03	123·64	10·00	10·78	74·01	58·09
1963	Neg	118·52	6·09	12·62	28·23	61·27
1964	139·75	107·76	24·97	11·81	79·29	70·27
1965	99·57	108·52	10·97	10·41	33·63	69·71
1966	183·46	158·19	7·02	9·23	136·18	77·02
1967	119·82	178·75	3·00	23·51	71·23	95·81
1968	248·34	190·08	0·18	21·86	64·77	102·17
1969	242·57	229·21	96·37	43·76	173·24	117·35
1970	156·22	267·61	2·73	43·49	65·45	109·07
1971	379·12	252·70	116·54	44·08	212·08	113·11
1972	311·80	284·88	1·64	57·69	29·83	137·99
1973	173·77	311·17	3·12	115·75	84·94	182·97
1974	403·50	295·53	164·41	120·07	297·66	177·44
1975	287·68	257·02	293·03	120·00	290·32	176·45
1976	300·92	264·93	138·17	149·21	184·44	194·67
1977	119·25	..	1·29	..	24·88	..
1978	213·29	..	149·15	..	176·06	..

ANNEXURE 4·8

West Bengal—Trends in areas affected by Floods and Damages

A : Area affected (lakh hectares) Reference to para 4·6·10

Year	cropped area		non cropped area		total area	
	annual	5 year moving average	annual	5 year moving average	annual	5 year moving average
1	2	3	4	5	6	7
1953	Neg.	–	Neg.	..	Neg.	..
1954	3·1*	..	1·1	..	4·2	..
1955	0·2*	1·46	3·3	7·70	3·5	9·16
1956	4·0	1·72	22·5	8·34	26·5	10·06
1957	Neg.	2·32	11·6	9·14	11·6	11·46
1958	1·3	2·32	3·2	8·82	4·5	11·14
1959	6·1	1·54	5·1	4·70	11·2	6·24
1960	0·2	1·58	0·7	2·66	1·9	4·24
1961	0·1	0·38	0·9	2·14	2·0	3·52
1962	0·2	0·20	1·4	1·28	1·6	1·48
1963	0·3	0·28	0·6	0·06	0·9	1·34
1964	0·2	0·32	0·8	0·88	1·0	1·20
1965	0·6	1·12	0·6	1·64	1·2	2·76
1966	0·3	2·96	1·0	3·96	1·3	6·92
1967	4·2	3·26	5·2	4·52	9·4	7·78
1968	9·5	4·94	12·2	6·62	21·7	11·56
1969	1·7	7·04	3·6	8·38	5·3	15·42
1970	9·0	6·48	11·1	7·94	20·1	14·42
1971	10·8	5·42	9·8	6·40	20·6	11·82
1972	1·4	5·50	3·0	6·02	4·4	11·52
1973	4·2	3·78	4·5	4·12	8·7	7·90
1974	2·1	1·94	1·7	4·44	3·8	6·38
1975	0·4	2·36	1·6	6·24	2·0	8·60
1976	1·6	4·18	11·4	8·68	13·0	12·86
1977	3·5	..	12·0	..	15·5	..
1978	13·3	..	16·7	..	30·0	..

* : Estimated
Neg : Negligible

Source : Basic data furnished by Central Water Commission

ANNEXURE 4.8—(*contd.*)

B. : Damage at constant (1952-53) prices

(in lakh Rupees)

year	crop damage annual	crop damage 5 year moving average	non-crop damage annual	non-crop damage 5 year moving average	total damage annual	total damage 5 year moving average
1	2	3	4	5	6	7
1953	4.74	..	10.41	..	15.15	..
1954	780.29	..	301.20	..	1081.49	..
1955	57.41	315.55	109.95	223.22	167.36	538.77
1956	734.65	414.58	238.07	252.71	972.72	667.29
1957	0.64	1019.77	456.49	357.66	457.13	1377.43
1958	499.91	1028.97	157.84	348.46	657.75	1377.43
1959	3806.23	892.20	825.97	314.98	4632.20	1207.10
1960	103.41*	902.08	63.96	225.23	167.36	1127.30
1961	50.79*	804.46	70.67	193.79	121.46	998.25
1962	50.04	52.28	7.70	36.04	57.74	89.02
1963	11.83	66.86	0.68	23.97	12.51	90.83
1964	48.83	73.45	37.22	11.70	86.05	85.15
1965	172.80	240.92	3.60	50.52	176.40	291.44
1966	83.77	736.99	9.28	360.73	93.05	1097.72
1967	887.38	796.15	201.88	413.62	1089.18	1209.79
1968	2492.18	1252.01	1551.74	645.80	4043.92	1897.82
1969	344.63	2247.36	301.70	945.23	646.33	3192.59
1970	2452.11	2147.56	1164.50	944.43	3616.61	3091.99
1971	5060.51	1864.74	1506.40	696.32	6566.91	2561.06
1972	388.38	1921.56	197.81	638.96	586.19	2560.52
1973	1078.09	1450.56	311.19	409.02	1389.28	1859.58
1974	628.70	529.83	14.89	129.60	643.59	659.43
1975	97.14	635.83	14.81	96.82	111.95	732.66
1976	456.86	467.82	109.29	326.86	566.15	794.68
1977	918.38	..	33.94	..	952.32	..
1978	238.02	..	1461.37	..	1699.39	..

ANNEXURE 4·8—(*concluded*.)

C : Damage per unit area.

(Rupees per hectare)

year	crop damage		non-crop damage		total damage	
	annual	5 years moving average	annual	5 year moving average	annual	5 year moving average
1	2	3	4	5	6	7
1953	*Neg.*		*Neg.*		*Neg.*	
1954	251·71		273·82		257·50	
1955	287·05	144·48	33·32	71·41	47·82	76·29
1956	183·66	221·39	10·58	81·28	36·71	105·52
1957	Neg	295·85	39·35	58·91	39·41	136·74
1958	384·55	341·85	49·33	59·77	146·17	144·79
1959	623·97	406·69	161·95	65·09	413·59	149·60
1960	517·05	456·73	37·62	58·32	88·08	148·93
1961	507·90	387·71	37·19	48·68	60·73	122·48
1962	250·20	311·75	5·50	25·59	36·09	56·97
1963	39·43	265·94	1·13	19·27	13·90	68·75
1964	244·15	220·20	46·53	13·69	86·05	70·92
1965	288·00	212·42	6·00	20·35	147·00	86·88
1966	279·23	257·00	9·28	45·56	71·58	121·37
1967	211·28	248·71	38·81	53·02	115·87	121·55
1968	262·33	245·60	127·19	72·80	186·36	131·14
1969	202·72	283·47	83·81	101·69	121·95	181·58
1970	272·46	296·70	104·91	107·11	179·93	181·05
1971	468·57	295·57	153·71	95·50	318·78	182·72
1972	277·41	314·90	65·94	80·49	133·23	192·20
1973	256·69	308·98	69·15	61·36	159·69	167·41
1974	299·38	272·38	8·76	32·54	169·37	112·36
1975	242·85	269·37	9·26	19·92	55·98	98·01
1976	285·54	221·61	9·59	23·59	43·55	77·40
1977	262·39	..	2·83	..	61·44	..
1978	17·90	..	87·51	..	56·65	..

सत्यमेव जयते

ANNEXURE 4.9

(Ref. para 4.6.13)

Orissa—*Trends in area affected by flood and damages.*

A: Area affected (Lakh hectares)

Year	crop area annual	 5-year moving average	non-crop area annual	 5-years moving average	total area annual	 5-year moving average
1	2	3	4	5	6	7
1955	4·10		2·5		6·6	
1956	0·9		2·4		3·3	
1957	Nil	1·4	Nil	3·0	Nil	4·4
1958	0·2	1·0	0·1	4·1	0·3	5·9
1959	2·0	2·5	10·0	5·0	12·0	7·6
1960	5·9	2·6	8·1	5·0	14·0	7·6
1961	5·1	2·8	6·7	5·0	11·8	7·8
1962	Nil	2·7	Neg.	3·5	Neg	6·2
1963	0·9	1·6	0·3	2·0	1·2	3·5
1964	1·6	0·6	2·3	1·1	3·9*	1·7
1965	0·3	1·1	0·5	2·1	0·8	3·2
1966	0·1	1·7	2·3	3·2	2·4*	4·9
1967	2·7	1·9	4·8	3·5	7·6	5·4
1968	3·7	2·5	6·2	3·4	9·9	5·9
1969	2·8	3·4	3·7	3·2	6·5	6·7
1970	3·2	5·3	Nil	5·8	3·2	11·1
1971	4·7	6·0	1·4	5·8	6·1	11·8
1972	12·0	5·7	17·7	5·2	29··7	10·9
1973	7·2	5·9	6·2	5·4	13·4	11·2
1974	1·2	4·9	0·7	5·1	1·9	10·0
1975	4·2	2·9	0·9	1·8	5·1	4·7
1976	Neg.	2·1	Neg.	0·7	Neg.	2·8
1977	1·9		1·2		3·1	
1978	3·3		0·8		4·1	

*Estimated

Neg : Negligible

Source : Basic data furnished by Central Water Commission.

ANNEXURE 4.9—contd.

B: *Damage at constant* (1952-53) *prices*

(in lakh rupees)

Year	crop damages		non-crop damages		Total damages	
	annual	5-years moving average	annual	5-year moving average	annual	5-year moving average
1	2	3	4	5	6	7
1955	904·71		274·32		1179·03	
1956	212·87		8·76		221·63	
1957	Nil	281·37	Nil	60·88	Nil	342·25
1958	9·01	428·57	2·25*	229·12	11·26	657·69
1959	280·28	590·48	19·05	228·46	299·33	818·94
1960	1640·69	590·67	1115·54	228·50	2756·23	819·17
1961	1022·40*	604·64	5·48	229·39	1027·88	834·03
1962	0·97	575·57	0·16	230·64	1·13	806·21
1963	78·86	257·21	6·72	7·83	85·58	265·04
1964	134·94	55·55	25·29	6·73	160·23	62·29
1965	48·88*	134·51	1·49	39·78	50·37	174·29
1966	14·12*	198·59	Neg	89·31	14·12	287·90
1967	395·75	266·31	165·41	125·73	561·16	392·04
1968	399·26	355·20	254·37	135·31	653·63	490·51
1969	473·54	512·23	207·39	239 56	680·93	751·79
1970	493·31	670·01	49·38	334·85	542·69	1004·86
1971	799·27	824·60	521·26	373·62	1320·53	1198·22
1972	1184·68	729·97	641·86	347·33	1826·54	1077·29
1973	1172·22	745·71	448·20	460·45	1620·42	1206·16
1974	0·36	586·13	75·93	358·04	76·29	940·18
1975	572·02	384·13	615·02	285·40	1187·04	669·53
1976	1·38	202·18	9·21	356·67	10·59	558·85
1977	174·69		278·62		453·31	
1978	262·43		804·56		1067·01	

ANNEXURE 4.9—concld.

C—*Damages per unit area*

(Rupees per hectare)

year	crop damage		non-crop damage		Total damage	
	annual	5 year moving average	annual	5 year moving average	annual	5 year moving average
1	2	3	4	5	6	7
1955	220·7		109·73		178·64	
1956	236·6		3·65		67·16	
1957	Nil	128·5	0	27·56	0	61·65
1958	45·0	140·0	22·50	33·16	37·53	65·30
1959	140·2	132·8	1·91	32·59	24·94	69·29
1960	278·1	132·8	137·72	32·59	196·87	69·29
1961	200·5	141·3	0·82	32·57	87·11	76·05
1962	Neg	130·1	Neg	34·39	Neg	79·28
1963	87·7	107·1	22·40	7·44	71·32	52·49
1964	84·3	95·2	11·00	7·28	41·88	36·25
1965	162·9	124·5	2·98	14·03	62·96	51·02
1966	141·2	128·6	Neg	17·75	5·88	49·96
1967	146·6	145·5	33·76	26·76	73·84	62·69
1968	107·9	143·8	41·03	26·17	66·02	84·02
1969	169·1	149·6	56·05	100·63	104·76	126·14
1970	154·2	140·0	Neg	101·13	169·59	123·67
1971	170·1	151·0	372·33	107·39	216·48	134·65
1972	98·7	117·2	36·26	117·87	61·50	121·73
1973	162·8	113·6	72·29	254·44	120·93	134·36
1974	0·3	79·6	108·47	180·08	40·15	91·07
1975	136·2	78·2	683·36	219·26	232·75	108·01
1976	Neg	61·6	Neg	405·94	Neg	135·88
1977	91·9		232·18		146·23	
1978	79·6		1005·70		260·25	

Neg : Negligible

ANNEXURE 4.10

Assam—*Trends in area affected by flood and damage*

A : Area affected (lakhs hectares)

(Ref. para 4.6.15)

Year	crop area		non-crop area		total area	
	annual	5 year moving average	annual	5 year moving average	annual	5 year moving average
1	2	3	4	5	6	7
1953	N.A.				0.8	
1954	2.7		28.8		31.5	
1955	0.9		13.2		14.1	11.28
1956	0.8	1.08	5.2	12.54	6.0	13.62
1957	0.3	0.92	3.7	8.48	4.0	9.40
1958	0.7	1.18	11.8	6.34	12.5	7.62
1959	1.9	1.06	8.5	5.64	10.4	6.70
1960	2.2	1.76	2.5	7.38	4.7	9.14
1961	0.2	1.78	1.7	6.02	1.9	7.80
1962	3.8	1.70	12.4	5.54	16.2	7.24
1963	0.8	1.30	5.0	6.38	5.8	7.68
1964	1.5	2.06	6.1	8.80	7.6	10.86
1965	0.2	1.44	6.7	6.70	6.9	8.14
1966	4.0	1.54	13.8	6.26	17.8	7.80
1967	0.7	1.44	1.9	6.16	2.6	7.90
1968	1.3	1.80	2.8	6.16	4.1	7.96
1969	1.0	1.22	7.1	3.90	8.1	5.12
1970	2.0	1.84	5.2	4.96	7.2	6.80
1971	1.1	2.16	2.5	9.32	3.6	11.48
1972	3.8	2.48	7.2	9.62	11.0	12.10
1973	2.9	2.10	24.6	8.58	27.5	10.68
1974	2.6	2.10	8.6	9.00	11.2	11.10
1975	0.1	2.24	Nil	8.86	0.1	11.10
1976	1.1	3.02	4.6	3.94	5.7	6.96
1977	4.5		6.5		11.0	
1978	6.8		Nil		6.8	

N. A. : Not available.

ANNEXURE 4.10—contd.

B—*Damages at constant* (1952-53) *prices*

(in lakh rupees)

Year	crop damage		non-crop damage		total damage	
	annual	5 year moving average	annual	5 year moving average	annual	5 year moving average
1	2	3	4	5	6	7
1953	201.14		51.09		252.23	
1954	1090.35		516.77		1607.12	
1955	283.12	394.81	135.52	208.45	418.64	603.27
1956	306.73	385.31	16.16	216.18	322.89	601.49
1957	92.73	272.17	322.72	153.24	415.45	425.41
1958	153.60	340.71	89.73	128.29	243.33	469.00
1959	524.65	286.31	202.08	127.39	726.73	413.70
1960	625.84	579.79	10.74	80.51	636.58	660.29
1961	34.73	580.20	11.69	63.83	46.42	644.03
1962	1560.11	507.08	88.29	24.42	1648.40	531.51
1963	155.68	389.81	6.34	22.77	162.02	412.58
1964	159.05	611.52	5.06	29.50	164.11	641.02
1965	39.47	319.22	2.48	12.41	41.95	321.63
1966	1143.31	362.84	45.31	16.66	1188.62	379.49
1967	98.60	378.36	2.84	43.66	101.44	422.02
1968	373.76	439.76	27.59	59.46	401.35	499.20
1969	236.64	249.65	140.10	58.21	376.74	307.86
1970	346.48	408.90	81.45	64.82	427.93	473.72
1971	192.70	430.94	39.05	64.74	231.82	495.68
1972	894.84	468.68	35.92	44.47	930.76	513.14
1973	483.95	400.96	27.19	28.26	511.14	429.22
1974	425.35	409.17	38.72	38.15	464.07	447.33
1975	7.89	353.69	0.44	52.62	8.33	406.31
1976	233.84	275.35	88.50	48.83	322.34	324.17
1977	617.43		108.24		725.67	
1978	92.22		8.22		100.45	

ANNEXURE 4.10—concld.

C—*Damage per unit area (Rs. per hectares)*

Year	crop damage per hectare		non-crop damage per hectare		total damage per hectare	
	annual	5 year moving average	annual	5 year moving average	annual	5 year moving average
1	2	3	4	5	6	7
1953					315·29	
1954	403·83		17·94		51·02	
1955	314·58		10·27		29·69	110·74
1956	383·41	326·07	3·11	25·23	53·82	51·57
1957	309·10	300·53	87·22	26·39	103·86	55·34
1958	219·43	294·51	7·60	25·20	19·47	76·49
1959	276·13	252·56	23·77	25·95	69·88	70·62
1960	284·47	272·85	4·30	9·93	135·44	70·19
1961	173·65	267·88	6·88	8·67	24·43	71·89
1962	410·56	233·86	7·12	4·08	101·75	62·23
1963	194·60	216·44	1·27	3·29	27·93	36·36
1964	106·03	238·87	0·83	2·57	21·59	44·83
1965	197·35	184·93	0·37	1·45	6·08	32·28
1966	285·83	203·52	3·28	3·16	67·68	46·27
1967	140·86	229·64	1·49	6·94	39·02	51·25
1968	287·51	224·82	9·85	10·00	97·89	61·92
1969	236·64	202·69	19·72	12·47	46·50	61·45
1970	173·24	221·62	15·66	13·17	59·43	70·56
1971	175·25	157·49	15·62	11·42	64·39	54·70
1972	235·48	182·88	4·99	8·38	84·61	53·69
1973	166·88	164·02	1·11	28·24	18·59	58·46
1974	163·60	171·49	4·5	5·97	41·43	56·90
1975	78·90	151·83	Neg.	8·30	83·30	53·17
1976	212·58	121·17	19·24	8·08	56·55	52·40
1977	137·21		16·65		65·97	
1978	13·56		Neg.		14·77	

ANNEXURE 4.11

Flood damage to crops and the domestic product from agriculture

Ref. para 4·7·1
(Rupees in crores)

Year	domestic product from agriculture in 1960-61 prices	flood damages to crops in 1960-61 prices	flood damages as per cent of domestic product
1	2	3	4
1953-54	10201	64·14	0·63
1954-55	10483	72·71	0·69
1955-56	10860	162·37	1·50
1956-57	11461	62·52	0·55
1957-58	11254	27·65	0·25
1958-59	12165	58·05	0·48
1959-60	12399	85·24	0·69
1960-61	13263	68·68	0·52
1961-62	13729	32·06	0·23
1962-63	13993	89·14	0·64
1963-64	14771	35·29	0·24
1964-65	15885	86·46	0·36
965-66	15082	4·35	0·03
1 66-67	15217	45·20	0·30
1967-68	16463	82·39	0·50
1968-69	16939	122·64	0·72
1969-70	18016	197·46	1·10
1970-71	19096	160·06	0·84
1971-72	19298	339·34	1·76
1972-73	19048	78·82	0·41
1973-74	20143	237·81	1·18
1974-75	20183	187·22	0·93
1975-76	21952	152·42	0·69
1976-77		295·34	
1977-78		1131·00	

Source : Basic data obtained from Central Statistical Organisation and Central Water Commission.

सत्यमेव जयते

ANNEXURE 4.12

Crop damage due to floods and State domestic product from agriculture at (1960-61) prices

Ref. para 4·7·3
(Rupees in crores)

Year	Uttar Pradesh			Bihar			West Bengal			Orissa		
	SDP from Agriculture	Crop damages	%	SDP from agricul- lture	Crop damages	%	SDP from Agricul- ture	Crop damages	%	SDP from Agricul- ture	Crop damages	%
1	2	3	4	5	6	7	8	9	10	11	12	13
1962-63	1018·18	18·17	1·8	490	8·99	1·8	496·34	0·58	0·1	265·21	—	—
1963-64	1120·85	16·61	1·5	578	0·69	0·1	590·19	0·14	..	306·62	0·91	0·
1964-65	1309·46	8·15	0·6	540	8·06	1·5	537·86	0·53	0·1	273·46	1·47	0·
1965-66	1159·41	0·07	..	572	1·18	0·2	501·26	1·86	0·4	223·49	0·25	0·
1966-67	1287·38	4·04	0·3	418	22·81	5·5	537·43	0·93	0·2	267·18	..	..
1967-68	1151·74	24·69	2·1	506	8·60	1·7	509·77	8·72	1·7	237·42	3·89	1·
1968-69	1056·90	3·99	0·4	494	4·87	1·0	541·49	25·72	4·8	268·89	4·12	1·
1969-70	1167·15	17·06	1·5	510	14·20	2·8	600·32	3·96	0·7	305·88	5·44	1·
1970-71	1171·69	20·51	1·8	558	7·03	1·3	638·24	29·04	4·5	315·07	5·84	1·
1971-72	1197·18	51·54	4·3	581	68·60	11·8	698·05	59·07	8·5	311·28	9·33	3·
1972-73	1421·00	1·20	0·1	628	0·68	0·1	574·21	4·24	0·7	357·94	12·94	3·
1973-74	1378·93	24·02	1·7	699	7·02	1·0	669·06	12·44	1·9	382·09	13·53	3·
1974-75	1172·52	15·14	1·3	645	77·64	12·0	558·19	6·91	1·2	276·78	.	..
1975-76	1039·26	8·05	0·8	N A	..	..	524·04	1·03	0·2	305·61	6·07	2·

%—crop damage as percentage of SDP from agriculture.

Source : Basic data relating to SDP from Central Statistical Organisation and flood damaged from Central Water Commission.

ANNEXURE 4.13

A : Area under and production of major Kharif crops in selected flood prone districts of Uttar Pradesh

Area : Hectares
Production : Tonnes
Yield : Kg./Hect.

Ref. para 4.7.9

Crop/district	percentage of crop area affcted to net sown area	1971-72			average 1969-70 to 1973-74		
		area	production	yield	area	production	yield
1	2	3	4	5	6	7	8
Paddy							
Varanasi	36.5	138,220	95,673	692	139,217	108,841	782
Basti	36.4	342,250	243,976	713	330,821	232,731	703
Sitapur	45.6	94,712	43,609	460	95,259	63,862	670
Gonda	25.5	235,639	151,111	641	239,900	159,055	663
Bahraich	93.9	182,657	79,248	434	169,938	101,098	595
Barabanki	57.7	130,334	120,161	922	126,421	105,937	838
TOTAL	48.3	1123,812	733,778	653	1101,556	771,524	700
Maize							
Varanasi	36.5	9,735	919	94	14,101	9,595	680
Basti	36.4	19,179	2,050	107	21,251	11,838	557
Sitapur	45.6	31,458	1,181	38	36,560	13,003	356
Gonda	25.5	89,281	3,334	37	99,366	55,310	557
Bahraich	93.9	143,206	15,645	109	147,521	81,339	551
Barabanki	57.7	12,226	1,185	97	12,668	6,345	501
TOTAL	48.3	305,085	24,314	776	331,467	177,430	535
Bajra							
Varanasi	36.5	12,917	5,574	432	16,172	15,979	988
Basti	36.4	18	9	500	59	49	830
Sitapur	45.6	7,188	1,537	214	7,720	4,640	601
Gonda	25.5	1,300	452	348	1,176	925	786
Bahraich	93.9	644	224	348	720	589	818
Barabanki	57.7	5,076	1,766	348	5,112	4,070	796
TOTAL	48.3	27,143	9,562	352	30,959	26,252	848
Jowar							
Varanasi	36.5	4,339	716	165	5,044	3,677	729
Basti	36.4	2	..	..	..	..	..
Sitapur	45.6	5,178	1,722	333	6,048	4,900	810
Gonda	25.5	1,126	404	359	1,087	751	691
Bahraich	93.9	824	295	358	720	500	694
Barabanki	57.7	6,654	2,386	359	7,068	4,922	696
TOTAL	48.3	18,123	5,523	305	19,967	14,750	739

Source : Agricultural Situation in India—Statistical Tables.

ANNEXURE 4.13—*concld.*

B : Area, production and yield of principal Kharif crops in selected districts of Bihar.

Area: Hectares
Production : Tonnes
Yield: Kg./hect.

Ref. para 4.7.9

Crop/district	percentage of crop area affected to net sown area	1974-75 area	1974-75 production	1974-75 yield	average 1972-73 to 1976-77 area	average 1972-73 to 1976-77 production	average 1972-73 to 1976-77 yield
1	2	3	4	5	6	7	8
Winter paddy							
Saran	41.9	167,964	124,536	741	166,126	131,108	789
Champaran	42.8	294,369	259,180	880	304,354	248,058	815
Darbhanga	61.3	298,045	223,567	750	314,288	247,307	787
Monghyr	34.4	174,821	202,891	1160	158,053	144,439	914
Purnea	44.1	348,469	299,542	860	366,865	298,081	812
Muzzafarpur	61.8	296,714	177,649	599	311,279	227,475	731
TOTAL	48.0	1580,382	1287,365	815	1620,965	1296,468	80
Maize							
Saran	41.9	127,321	53,399	419	120,165	115,164	95
Champaran	42.8	38,194	34,728	909	35,728	39,943	111
Darbhanga	61.3	71,920	76,471	1063	72,938	72,793	99
Monghyr	34.4	118,438	91,896	776	138,677	122,210	88
Purnea	44.1	50,811	35,041	690	44,023	45,166	102
Muzzafarpur	61.8	86,358	52,472	608	85,626	70,967	82
TOTAL	48.0	493,042	344,007	698	497,157	466,243	9

Source : Agricultural Situation in India—Statistical Tables.

V. METHODS OF FLOOD MANAGEMENT

5.1. Approaches

Various approaches are available for tackling the problem of floods. Each situation is different and we should have different alternative adjustments or a combination of adjustments from which to choose. Basically, the adjustments can be classified into 4 main groups, each of which represents an attempt either to deal with the flood waters or the activities that would be affected by them*. The 4 groups are:

(1) Attempts to modify the flood;

(2) Attempts to modify the susceptibility to flood damage;

(3) Attempts to modify the loss burden;

(4) Bearing the loss.

Attempts to modify the flood involve flood protection by means of physical controls, flood mitigation by land use modification of the catchment or alteration of precipitation patterns through weather modification.

Attempts to modify the damage susceptibility involve actions designed to reduce the volunerability of property and activities in the flood plain to the flood hazard.

Attempts to modify the loss burden consist of actions designed to modify the incidence of the losses either by spreading them over a larger segment of the community than that immediately affected, or spreading them more evenly over time.

Bearing the loss connotes living with floods.

5.2. Modifying the flood

5.2.1. Methods for modifying the flood aim at changes in the volume of run-off, in the time taken to attain the peak, in the duration of the flood, in the extent of area flooded, in the velocity and depth of flood waters and in the amounts of sediment and pollutants the floods carry. These methods can be grouped under the following 3 heads:

(a) Construction of flood control or protective works;

(b) Adoption of measures which will cause reduction of floods;

(c) Alteration of precipitation patterns through weather modifications.

5.2.2 Flood control or protective works are undertaken in the channel phase of flood management. The objective is to control a flood, and aims to minimise the damages it may cause by regulating the flow or by preventing it from reaching the damageable property. It may involve the construction of works such as embankments and flood-walls, dams or reservoirs, detention basins, channel improvements, emergency flood-ways, river diversions, bank stabilisation, anti-erosion measures, ring bunds, underground storages also help to modify floods.

5.3. Control/protection works

5.3.1. *Embankments and flood walls or dowel walls*

The oldest, the most common, quickly constructed and often an economical means of flood protection is a system of embankments, leaving the river more or less in its existing course, and without attempting to modify the flood magnitude. Embankments are constructed on river banks in a general direction parallel to the flow of the river so that they can serve as artificial high banks of the river during floods. The usual construction material is earth. Because of their shape, even moderately high embankments occupy a large base area and in terms of land costs can be prohibitively costly in urban and industrial locations. In cases of spills of limited depths, masonry or concrete walls are at times constructed over the flanks of a suitably situated road or canal bank; these are called dowel walls. In developed areas where adequate space is not available or land is too expensive for an earthen embankment, concrete or masonry flood walls are constructed in place of embankments.

The embankments or their versions discussed above, serve the purpose of preventing the river water from spilling over the countryside. Their appeal lies in their direct and specific results. There is, however, divergence of opinion about the role of embankments in respect of their efficacy and side effects, these are briefly discussed below.

(a) *Prevention of silt laden water from spill over the land*

(i) *Effect on land*: Embankments have a direct impact on the land protected by them as well as the rivers along which they are constructed since they prevent the access of silt laden spill water into the protected areas. This deprives the land of the benefits of the fertilising and land building silt. On the other hand, without the embankments, silt used to be deposited over the country side during the rising flood, resulting in the return of comparatively silt-free water to the river at the time of the receding flood. Thus the construction of an embankment results in higher concentration of silt charge in the river and this may, at times, cause deterioration of the river.

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*UN Publication—Natural Resources/Water Series No. V—Guidelines for Flood Loss Prevention and Management in Developing Countries—1976.

Moreover, there is no conclusive study to establish the so-called fertilising effect of silt. From the study of the different project prepared by the States, it is observed that while working out the B.C. ratio, the monetary value of the fertilising silt is either completely ignored or taken as very nominal compared to the damages prevented by protection. In fact, sometimes instead of the fertilising silt, the flood waters when spread over the flood plain, affect productivity of the land.

The land building effect of floods is more important in low lying areas and even there, the process is very slow. In fact, in some of the areas the spill waters cause land erosion instead of land building. Thus, land building by flood waters is not always a positive benefit.

(ii) *Effect on river regime*: As explained above, in certain cases, construction of embankments, results in an increase in the silt charge of the flood flow. At the same time, embankments tend to increase the velocity of the flood flow and, as such, enable the river to carry an increased silt load. Thus, after the construction of embankments, while some rivers show a tendency of rise in bed on account of progressive siltation, there are others, which remain stable. The nature of the river and the silt charge carried by it, will have to be studied for likely adverse effects on the regime of the river due to embankments. If such a study shows that the regime is likely to be adversely affected, this measure may have to be avoided or carried out in conjunction with other suitable measure(s).

(iii) *Reduction of cross-sectional area of flow*: Embankments and flood walls have often been constructed close to the river bank and parallel to its course. In such situations, the discharging capacity of the flood-way between the embankments is very much reduced causing general increase in flood stages upstream and downstream of the embanked section. Also, in the case of meandering river in the alluvial reach, the embankments are continuously threatened by erosion. Therefore, embankments should be located as far away as possible from the river channel.

(iv) *Cutting off of Valley storage*: Another result of the construction of embankments is that the flood waters are prevented from spilling over a part of the flood plains, which deprives the river to that extent of the flood plain storage also known as valley storage otherwise available for moderation of the flood. The reduction in valley storage increases the intensity of flood discharge in an embanked river with accompanying rise in high flood level. It is interesting to observe in a river of very large capacity with a number of tributaries with widespread catchments that the maximum observed flood in the main river is only a small fraction of the aggregate of the maximum observed flood discharges in its tributaries. This is attributable to the existence of valley storage in the river and its tributaries as well as to the non-synchronisation of the floods from the tributaries with those of the main river.

(v) *Problem of aggradation*: The aggradation of the river caused due to the construction of an embankment, poses a threat to the safety of the embankment itself. On account of the progressive rise in the bed levels, the high flood levels also go on increasing and exceed those of the previous years for the same discharge, with the result that, if the embankment has to continue to give the same degree of protection as initially designed, the progressive raising of the embankment becomes inevitable. If so, a stage may come when it may no longer be possible to contain the river by the embankment. Also if a breach were to occur under such circumstances, there is not only the danger of greater devastation but also the possibility of an evulsion of the river into a new channel. Another difficulty under such a situation is that when the dry weather water level in the river becomes higher than the countryside level, the continuous seepage round the year through the embankment and the sub-soil beneath the embankment may cause extensive waterlogging of the countryside. The effect of an embankment on the river regime, and the pattern of floods in the post-embanked condition need careful study, as under adverse conditions, the changes brought about by the embankment may cause adverse side effects which would reduce the overall benefit of the remedial measure.

(b) *Effect of embankment on countryside dranage*

The construction of an embankment cuts off the natural drainage from the protected areas into the river except through predetermined drainage sluices provided in the embankment. Obviously, the total capacity of the drainage sluices cannot be made equal to the pre-embanked waterway available for natural drainage of the countryside into the river. Further, drainage sluices will be inoperable when the river stage is high. The position gets further aggravated in cases where flood levels increase due to silting. On the other hand, even in the pre-embanked condition, there would have been no prospect of the countryside waters draining into the river when the latter is in spate. Besides, the volume of water required to be drained from the countryside in a post- embanked condition will be much less than what it would have been in the pre-embanked condition due to the fact that there would be no spills from the river any more.

(c) *Drainage congestions at tributary junctions*

Embankments and flood walls must inevitably cross the tributaries of that river. In such cases, the alternatives are either to embank the tributary stream to the same level as the main river and to try the embankments to high ground at some appropriate point upstream or to block the tributary channel. This latter method will create and internal drainage problem behind the main channel embankment. The problem can be treated according to the regime and size of the tributary channels by adequate sluices, pumping, diversion or provision of adequate flood storage reservoirs.

(d) *Vulunerability of embankment to river action*

Generally, an embankment cannot be provided with all the safety measures for protection against unforeseeable attack by the river, both in respect of the time and place of attack. However, when the actual threat of erosion from a river becomes imminent, costly anti-erosion works become necessary at short notice, which if not carried out may jeopardise the protection offered by the embankment.

(e) *Vulnerability of embankments due to deficiency in planning/construction*

Sometimes, embankments are taken as an urgent measure and are completed in short time. Under such situations or when suitable materials are not available nearby they are not constructed to the required standards and so, may fail due to erosion, over-topping, seepage, leaks, cracks and foundation failure, causing considerable damage to life and property.

5.3.2. *Reservoirs*

The overbank spilling of a river resulting in floods, usually does not occur over a long period even during the flood season. The floods of high magnitude are caused mainly by severe storms and when the storm is over or gradually moves away from the catchment, the flood also subsides within a reasonable period. This fluctuation in flood discharge due to heavy precipitation, followed by a relatively drier spell, is taken advantage of for moderating the flood through a storage reservoir by storing the water during the time of high discharges and releasing it when the critical conditions are past. The simplest form of a flood control reservoir a is one where the dam is equipped with an ~~un~~controlled outlet|spill-way. Now-a-days we have large reservoirs, releases from which are made through outlets, spill-ways, penstocks etc., all controlled. The controlled storage reservoirs are operated by a regulation schedule which aims at impounding part of the in-flowing flood above a certain safe intensity during the rising stage. When the storage capacity is utilised, depending on the inflow, the outflow is stepped up to ensure that the design reservoir levels are not exceeded. Thereafter, the impounded flood water is released in such a regulated manner, as to empty the reservoir within a reasonable period for receiving the next flood, but at the same time, keeping the release rate as far as possible within the limits safe for the lower valley. In uncontrolled reservoirs, the outflow starts at a pre-determined reservoir level, and its rate is a function of the volume of storage and outflow rating at different reservoir levels and the flood peak at the dam usually gets reduced. This reduction of the peak is more with small floods than in large ones, because during large floods much of the reservoir space is already taken up before the peak arrives. Uncontrolled reservoirs are emptied automatically after each flood and, therefore, the land below the maximum flood water level can be used for low intensity agricultural purposes for most of the time.

Reservoirs can, as a general rule, control the rate and timing of the flood that may be let out. Their efficiency can be increased considerably with a reliable forecast of the inflow. Reservoirs also offer wide potential for multiple use of which flood control may be one. Reservoirs by themselves are seldom a complete measure of flood protection. Often embankments along the river in the downstream reaches are required as a supplementary measure to contain the residual floods.

Reservoirs occupy a substantial area and modify stream behaviour and habitat in both beneficial and adverse ways. The effect of flood moderation through reservoir storage does not usually travel far downstream of the structure. There is also the problem of a false sense of security which leads to encroachments upon and deterioration of the river channel downstream. This can lead to serious damages when a large flood has to be let down from the reservoir.

In a multipurpose reservoir the interests of the various components like irrigation, hydro power generation and flood control are usually at variance with one another even when the reservoir is owned by a single State. This conflict is much more pronounced when more than one State/country is involved. Irrigation and hydro, for example, would like the reservoir to be filled up as soon as it could be done and retained at as high a level as possible whereas flood control would require the reservoir to be kept as low as possible and also to be depleted at the earliest after use for flood absorption in a flood event. Multiple use of reservoirs, therefore, implies a compromise which inevitably results in less than the maximum possible benefits for any one use but which realises the maximum benefit for the project as a whole subject to availability of accurate flow forecasts in good time. As such forecasts are inadequate, effectiveness of multipurpose operation is severely limited and flood moderation is the worst sufferer. Thus a reservoir is more effective for flood control if, apart from the incidental moderation available with any type of storage on a river, some specific flood space is allotted for it. Therefore, to meet the needs of flood control, designated space as in the DVC reservoirs should be reserved and not encroached upon in any case. Also this space should be emptied out as soon as possible after each flood event. The moderated flood outflow should take into account the safety of the downstream area. Flushing doses not exceeding the discharge against which protection is given in the valley, should be released, in order to keep the river channel alive and as a deterrent to encroachments in the flood plains. Where no flood space is specifically provided it may be more helpful to provide a flood lift by designing the MRL suitably higher than the FRL.

The actual regulation of a storage reservoir is a complex process. One has to judicially anticipate the likely inflow to enable utilisation of the available storage space for maximum beneficial moderation/other uses. The need to make quick releases with a view to empty the reservoir so as to accommodate a succeeding flood should not overlook the vulnerability of the lower valley against higher discharges than what it can receive safely. The releases from a reservoir have also to take into account the contribution from the uncontrolled catchment below a dam site.

Thus some of the factors that need serious consideration before taking up reservoirs on a larger scale for flood moderation are:

(i) The effectiveness of flood moderation through storage reservoirs reduces considerably, if there is a large free catchment, downstream of the dam, upto the flood affected zone, for, the contribution from the uncontrolled catchment can be significant and flood moderation effect of the reservoirs in the upper basin is greatly reduced at the lower part of the basin. In such cases, the moderation provided by reservoirs needs to be supplemented by embankments to contain the residual floods. Another point to be kept in view is that the larger releases from the dams should be so timed as to arrive after the inflow peak of the intermediate catchment has passed. Even a small mistiming can lead to aggravation rather than an amelioration of flood conditions.

(ii) Depending upon the type of reservoir, land requires to be temporarily or permanently submerged in order to protect some other land. It is possible that the area flooded by a proposed reservoir may bear a high proportion to the area protected from floods. Since some of the good sites have already been utilised, the ratio of flooded area to protected area will tend to increase in the future. The burden of sacrificing land for the reservoir falls on a community which has no tangible flood problem. This situation generates considerable opposition to reservoirs.

(iii) The flood problem being more acute in the basins of rivers originating from the Himalayas, the reservoirs for flood moderation have to be sited in the Himalayan region, where there are complex problems to be dealt with in putting up large dams, due to geological, seismic and topographical constraints. Because of narrow valleys, capacities of reservoirs on Himalayan rivers are not very large. Also, the rivers carry very high silt charge. These factors limit the economic life of the reservoirs which, in turn, affects the economic feasibility of the project.

(iv) We may not have always a suitable reservoir site for controlling floods.

(v) The continues moderation of floods deprives the lower reaches of the flushing dose of high floods which is reported to be the cause of deterioration of the channel in the lower basin in some areas. The problem gets further aggravated by human encroachment into the flood plains of the lower basin, on account of the drastic reduction in the incidence and intensity of floods achieved by upland reservoirs. All these lead to a condition where even moderated releases during peak inflow, in conjunction with the contribution from the uncontrolled catchment become too much for the available channel capacity and cause damages exceeding those in the pre-reservoir period.

(vi) The trapping of silt in the reservoir can disturb the equilibrium between the discharge of water and sediment load on the one hand and the form of the channel on the other. This may increase erosion of the bed and sides of the channel as has been reported in the case of Maithon Dam. However, the effect of retrogression would generally tend to reduce flood levels.

(vii) Reservoirs do modify water quality not only in terms of suspended sediments, but also in terms of temperature and chemical content with the result that they can disturb the natural ecological balance. The dam itslef can seriously affect migrating species.

(viii) Though uncommon, dam failures do occur due to floods and they cause catastrophic damages. They are more due to the inevitably intensified land use downstream of the dam on account of the security afforded by the flood protecting reservoir.

5.3.3. *Natural detention basins*

Moderation of flood can also be effected by utilising natural depressions, swamps or lakes, to which a portion of the flood discharge from the main river could be diverted. Normally, where the topography permits, a regulating device is provided for letting in and storing the water in a regulated manner and releasing it back into the river after the river flood peak starts receding, through the same regulating structure or through another one lower down, in a regulated manner, to have the desired flood moderation. Storage capacity of the natural topography can also be enhanced under favourable circumstances by putting up embankments along the periphery of the depression and margins of channels connecting successive basins or depressions.

This type of flood moderation is relatively cheap as compared to that through an artificial reservoir provided a suitable depression or swamp or natural lake exists near enough to the flood prone area in the basin.

5.3.4. *Channel improvement*

A stream can be made to carry its peak discharge at levels lower than its prevailing high flood level, by improving the carrying capacity of the channel. This method will help to reduce the prevailing water level for the corresponding flood discharge, with the result that the banks of the channel are either not overtopped or over-topped less frequently. Such improvements may be accomplished by (a) increase in size of cross-section , (b) increasing velocity of flow in the channel.

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(a) *Increase in channel section*

This is done by widening or deepening the channel—in other words by increasing the cross-sectional area. Such an increase is economically practicable only on channels of small streams carrying a manageable high flood discharge, as the whole width of the stream has to be excavated to about the depth by which reduction in water level is desired. In the case of larger rivers, such a method is generally impracticable on account of the huge capital and maintenance costs for dredging and the impracticability of disposing of the excavated material over developed areas. This method may be useful where construction or improvement of embankments is extremely expensive or where local channel improvements can reduce water levels for a long distance upstream.

(b) *Increase in velocity*

Velocity of flow in a channel can be increased by taking recourse to (i) deepening, (ii) straightening and shortening the length by cut-offs, (iii) removing barriers in the section and lastly, (iv) by lining the channel to improve its co-efficient of rugosity.

The deepening of channel to increase the velocity is usually impracticable in the outfall reach, because the stream outlet into a river or the sea cannot normally be lowered. Non-uniform lowering of channel bed, on the other hand, due to deepening a particular upstream reach of the stream, may result in increased velocity in that reach, but will not have any useful effect in the reach lower down where such deepening is not done.

The straightening and shortening of the channel length by having cut-offs along the meander loop of a stream, is fraught with the danger that the same tends to increase the flood height immediately downstream of the cut-off and induce a relatively high velocity in the region of the cut-off, which may eventually develop into a serious bank erosion problem. Judiciously planned cut-offs have, however, been extensively used for channel improvement of all sizes of rivers.

Removal of barriers covers cleaning of river banks of the brush, trees and other obstacles which impede the flow. Streams flowing through varying bed material, particularly in the incised rivers, may have a natural barriers in the bed, which prevents free flow. Removal of such barriers increases the velocity of flow of the channel and reduces the flood stage. Increasing of the waterway and other improvements for quicker disposal of floods at drainage crossings will also reduce flood stages at these points.

Lining of the channel to improve its rugosity co-efficient and thereby the discharge capacity of the channel, is practicable only for smaller streams. Due to the costly nature of this method, it is not usually adopted in this country. This method is effective where the sediment load is less. In urban areas such lined channels may be a hazard to the safety of life unless suitable fencing arrangements are made.

If a channel presently in equilibrium or quasi-equilibrium is enlarged, straightened or steepened, the natural fluvial processes tend to reduce the cross section area and/or the slope by means of deposition. In addition, shallow water depth in oversized channels greatly increase weed growth during low flow periods with consequent increase in channel roughness which, in turn, encourages further deposition. So, channel improvement may call for costly maintenance like dredging and weed control entailing expenditure which would set a low limit to the level of protection afforded by channel improvement schemes in agricultural areas. Another major disadvantage of channel improvement is that the more rapid flow of water through the hydraulically improved channel section can aggravate flood problem further downstream and even cause excessive channel erosion upstream or downstream of the improved reach. Also, the lowering of water levels in the improved reach may cause overdrainage of adjacent agricultural land calling for construction of sluices in the channel to maintain water levels during periods of low flow and to conserve water for upper riparian use. In other circumstances, no doubt, the improved drainage of riparian lands may be helpful and also, by improving sub surface water storage capacity, flood producing quick flow can be substantially reduced. Therefore, channel improvements should be taken up after considering all these effects so as not to allow the flood problem to be shifted from one place to another.

5.3.5. *Emergency flood ways*

Another effective way to deal with floods is to take the excess water away from the river flows. This can be done in two ways, either by a temporary diversion or by a permanent diversion. Temporary diversions will come under 'emergency flood-ways' which make use of the flood plains and do not call for excavations to carry away the excess water. Permanent diversions will come under 'river diversions' and are dealt with in the next paragraph.

A primitive way of accomplishing the temporary diversion is to breach an embankment intentionally in an area where the damage may be relatively small in order to save the embankments that protect areas where damages may be very much more. When this principle of emergency flood escape is planned in advance and when suitable measures are taken, the result can be a very effective and relatively inexpensive method of flood control. The land under the flood ways is normally used for agricultural and other limited purposes during flood free periods.

The requirements for taking up such a measure are:

(i) the area into which the flood waters can be diverted is free of habitation,

(ii) the flood way is protected by secondary embankments to prevent flood waters from spreading in all directions,

(iii) there are reasonable drainage facilities to get the water back into the river after the flood is over, and

(iv) there is reasonable control over the water diverted into the emergency flood way.

Dynamiting the embankments may be considered as an emergency measure. But the proper arrangement would be to have a section of the embankment built with crest spill-way or spillway with sluices and the requisite energy dissipators.

It may be seen that wide flood ways provide storage capacity as well as discharge capacity but involve large areas of the flood plain. But, this depends entirely on the topography and the development of the flood plain. In the early days when no development had taken place, large areas could be set aside for flood ways. With increasing population and rapid development in the flood plains, especially near urban areas, flood ways are not easily possible and only diversion channels can be considered.

5.3.6. *River diversions*

Schemes for permanent diversions of flood waters come under river diversions. These can be employed for lowering water levels by diverting all or a part of the discharge into a natural or artificially constructed channel, lying within or in some cases outside the flood plains. The diverted water may be taken away from the river without returning it further downstream or it may be returned to the river channel some distance downstream or to a lake or to the sea. When it is diverted into another stream, the diversion scheme becomes an interbasin transfer. But this type of diversion is less common than the diversion channel which protects a certain specific area and, therefore, the diverted water is returned to the river at a point downstream, where the backwater effect will not be felt. This also can be difficult and expensive. In a diversion project, the total cost will depend on the cost of excavation. If the purpose is only to reduce levels in a specific reach, a control dam just downstream of the off-take of the diversion channel will reduce the quantity of excavation in the diversion channel but the economics will have to be worked out. It is also possible to construct part or all of the diversion channel with two embankments on the flood plains which would make the flood way. An example in India of this type is the flood spill channel of the Jhelum river bypassing Srinagar.

Diversion of flood waters by the provision of emergency flood ways, or diversion channels is largely influenced by the topography and the degrees of development therein. The proposed diversion needs considerable study to examine the availability of suitable hydraulic conditions in the flood-ways during critical periods of floods and to determine whether synchronisation of floods in the two neighbouring basins would adversely affect the prospect of inter-basin transfer of flood waters. Usually temporary diversions will be less expensive than channel improvements involving demolition of property. Diversions are more effective when the diverted water is completely removed from the normal channel and not returned to it further downstream.

5.3.7. *Inter basin transfer*

As noted earlier, when the diverted water is allowed into an adjacent stream or drainage basin the method adopted is termed inter-basin transfer. This will always involve excavation of a large magnitude or tunnelling through the ridge. This method is not economically feasible except in cases of small streams and where the watersheds are separated by flat ridges.

Inter-basin transfer has been extensively used in the lower Missisippi valley and in the Sacramento river valley in the USA. These have been used as substitutes for embankments or flood walls wherever urban developments are concentrated near the channel banks.

5.3.8. *Bank stabilisation and anti-erosion measures*

These measures are adopted to train the river so as to check its tendency to erode and damage new areas. Alluvial rivers are usually meandering and, therefore, raise problems of erosion and silting at various locations. This process is a natural phenomenon and results in loss of land at one location and gain at some other.

Anti-erosion works aim at deflecting the current away from the area or structure under attack by the river. They usually comprise spurs of earth protected by armour stones or spurs of loose stones or stones in wire-mesh crates. Revetment works along the banks or embankments also belong to the category of anti-erosion works. If the current is strong and undercuts the bank, as is very often the case, spurs and projections into the waterway are sometimes damaged seriously or even washed away. Therefore, anti-erosion works are expensive both in construction and maintenance.

Spurs, as explained earlier, change the direction and attack of the river current and result in shifting of the problem upstream or downstream which may affect either bank. These aspects need careful consideration before such works are undertaken.

Erosion of land at one place and rebuilding at another, being a normal phenomenon, anti-erosion works are justified only for the protection of towns or groups of highly populated abadis, communications like railway lines and roads, places of strategic and religious importance etc., where relocations are found to be not technically feasible or much too expensive. They can also be justified for protecting long lengths of embankments benefiting large areas which are threatened by the current. For smaller lengths of embankments, retirements will be more economical. This measure is not economical for protection of agricultural lands on account of the high cost and maintenance involved.

5.3.9. *Ring bunds*

Sometimes, a flood modification measure consisting of a ring bund around habitations is adopted. This measure has been recently adopted by the Haryana State. While ring bunds help in keeping the habitations free from inundation, there is the inherent disadvantage that the rain water which accumulates within these bunds, needs to be drained out. To evacuate the collected rain water, installation of pumps becomes necessary. These pumps are costly in operation and unless properly maintained pose the danger of not being in working condition at crucial times. Ring bunds also need to be linked by a high bank with high ground for ensuring proper communications during flood seasons. The link bund along with the ring bund can cause a threat by changing the direction of the main flood as the combined unit can function as a spur projecting into the flood way.

5.3.10. *Underground storage reservoirs*

One more method of flood modification could be to augment the underground water storage with surplus flow during the monsoon season and use it in the post monsoon season for irrigation and other purposes. Such ground water storage of flood waters occurs naturally when flood plains are inundated, especially in arid and semi-arid conditions when the initial water table is at considerable depth below the ground surface. Ground water storage can be induced artificially through the use of water spreading in shallow basins and by means of injection wells specially driven for the purpose. This technique has so far been adopted for water conservation only. Its applicability for flood mitigation on a large scale is yet to be tested.

5.4. Measures for Abatement of floods

Watershed management or land treatment approach to flood abatement aims at cutting down and delaying the run-off before it gets into river channels. It operates in the land phase of the flood while the types of flood control measures described earlier deal with floods during the channel phase. This approach has gained considerable support in certain circles advocated by the soil conservationists under slogans like 'stop the little rain drops where they fall'. The control of water and soil in the land phase is attained by implementing an integrated programme of engineering, agronomy and forestry.

The land treatment programme relates to engineering measures which *inter-alia* include trenching, check and headwater dams, outlet structures, spurs, groynes, small reservoirs and tanks.

Under agronomy, the aspects concerning flood control for cultivated zones are introduction of suitable soil-protecting type vegetation and crops and also prohibition of cultivation on steep slopes. The methods for pasture lands are introduction of improved pasture management by

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cultivation of suitable grass and prevention of over-grazing.

Under forestry, the methods are afforestation, better forest management and elimination of shifting cultivation.

All the aforesaid methods, incidental to the main objective of land development, also improve the water infiltration capacity of the soil and reduce soil erosion.

Watershed management is generally advocated to be used in conjunction with other flood control measures. Successful adoption of flood abatement measures hinges upon vigorous efforts of Governmental agencies to inform farmers and other land users of the advantages of such measures and the provision of financial assistance to undertake them. Although useful, the precise role and cost effectiveness of watershed management is yet to be established as far as its ameliorative value on the flood mitigation problem is concerned.

Maximum absorptive capacity of soil is available only after a long dry spell. As large floods, which cause devastation, are almost invariably associated with prolonged periods of rainfall (during which the soil becomes nearly saturated) watershed management can have no significant effect on large floods. In a large catchment area, the inchannel travel time of the flood peak is so extended that the effects of catchment management in delaying the arrival of water at the stream channels is virtually insignificant. The major effect of improved watershed management on reducing peak flow is thus limited to the smaller floods, and that too, only for small catchments, the effect reducing to a lower degree for larger catchments. On the other hand, flood control projects have to be designed for floods of higher magnitudes. There are some conditions such as swamp lands or area of high precipitation over steep slopes and shallow soils where flood producing quick-flow will be generated whether or not a forest cover exists. Therefore, watershed management does not have any effect on the size and cost of sizeable flood control works.

One side effect of land treatment measures which can be injurious in some places is that "when flood flows are reduced, low flows may also dminish".* In other works "the same principle that tends to reduce floods from land areas during flood times, also acts to reduce the amount or quantity of stream flow during critical low periods."**

From the angle of flood modification, the more important contribution of watershed management is reduction in silt charge. In rivers of aggrading nature, reduction of silt charge will tend to stabilise the river under favourable conditions. The reduction of silt charge will also increase the life of storage reservoirs, and stabilise the benefits of embankments. It is, however, to be recalled that watershed management can reduce only sediment load from land erosion from human activities but the natural forces, like earthquakes, avalanches, land slides, bed scour in steep gradient reaches of hilly streams shall continue to contribute silt. The river is also likely to pick up silt during its passage through the alluvial plains.

Watershed management is thus likely to give some benefit to flood mitigation works, by reducing the silt load. However, with the limited experience now available, quantitative assessment of the same cannot be made. Whether the reduction in silt charge will be tangible and whether it will again be wiped out by scooping up of the scourable bed material of the rivers and streams of steep gradient, is still to be tested. Thus, the evaluation of watershed management programmes in relation to flood benefits is yet to be made under prototype conditions, especially for Himalayan watersheds.

5.5. Weather modifications

Weather modification has sometimes been suggested as a likely method of flood modification. This method would attempt to redistribute the precipitation both in respect of time and space, and thereby reduce the risk of high floods in a given area. As such, it would constitute an "atmospheric phase" in flood management. At present, however, weather modification is more a concept than a reliable means of altering stream flow pattern. Some efforts for producing rains by seeding of clouds have been made in the experimental stage, but they are mainly directed towards producing more rain.

A number of research programmes for determining the possibilities of altering the weather in a reliable and consistent manner are under way in various parts of the world. Even assuming that the methods are successful in modifying weather, it is not clear that the overall gains would exceed the overall costs. Further, the redirection of a storm may reduce the damage to property in certain areas, but increase it in certain other areas. It may also deprive certain areas of the rainfall upon which they depend for agriculture, industry, domestic water supply etc. Also, it has to be considered whether economically more efficient means of providing the same benefits can be found. Over and above that, it also needs to be examined whether the ecological impact of weather modification would be significant and the likely effects that may arise among different regions, States or countries as a result of its adoption. In fact, weather modification may need even international regulation as its effctes would extend far beyond the area where the modification takes place.

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*The UN Publication National Resources/Water Series No. 5 "Guidelines for flood loss prevention and management in developing countries" — 1976.

**K. K. Framji and B.C. Garg— "Flood Control in the World, a global review Volume II— Country report of USA".

5.6. Modifying the susceptibility to flood damage

Flood modification, acting alone, leaves a residual flood loss potential. It can also encourage a false sense of security lending to inappropriate use of lands in the areas that are directly protected and often in adjacent areas as well. For this reason, measures to modify possible flood should usually be accompanied by measures to modify the susceptibility to flood damage by land use regulations.

The second approach for flood management is by modification of the susceptibility to damages of property and activities in the flood plain. This approach is usually carried out by flood plain management, development and redevelopment policies, structural changes, flood proofing, disaster preparedness and response plans, and flood forecasting & warnings. This strategy is expressed as actions to avoid dangerous, uneconomic, undesirable or unwise use of flood plains. Experience in other countries has shown that such adjustments are very effective and that they cost less than conventional measures. Also, this approach tends to pass the burden of costs from the public at large to those who reap the advantages of flood plain location with the result that it also promotes increased awareness of the need for efficient flood adjustments.

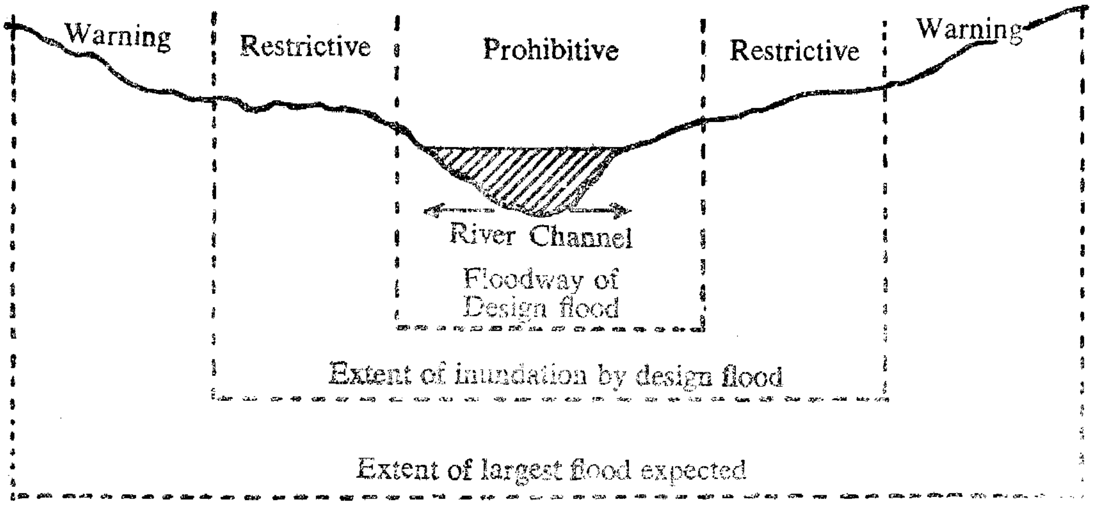
5.6.1. *Flood plain management*

Flood plain management covers land use regulations, statutes, zoning ordinances, sub-division regulations, Government purchase of property and relocation.

The concept of land use regulation for the reduction of flood damage recognises that it is the nature of a river to burst its banks from time to time and to spill out on to its flood plain when the river discharges are very high. The flood plain is an integral part of the river system even though it is used only occasionally to pass down flood flows. When the flood plain is not occupied by water, it forms part of the land system offering possibilities for agriculture, urban development and other economic activities. The purpose of land use regulation is to implement patterns of land use which, while taking advantage of the benefits offered by flood plain, reduce the damage suffered during the inevitable periods of flooding to a minimum. Land use regulation requires individuals, when making the decisions, to recognise the general welfare.

Likely losses in the flood plain tend to vary with the type of use to which the land is put. Thus, such losses are highest on the land used for urban or industrial purposes, lower for agricultural use and lowest on land set aside for recreational purposes. There would, of course, be no losses on land that is not used at all. However, it would not be realistic to keep all development out of the flood plain nor is it necessarily the most economical or sensible course of action. The best course would be to determine such activities as can be located in the flood plain and still pay the "natural tax" exacted by the flood plains. If an activity cannot afford to pay the "natural tax", it should not be allowed to use the flood plain. A set of regulations based upon this concept helps the potential flood plain occupants to examine carefully locations both inside and outside the flood plains.

The purposes of land use regulation within a flood hazard area are two-fold: (i) to ensure that the existing hazard and flood damage potential are not increased, and (ii) to ensure that new developments are not themselves subjected to serious damage. The flood zone concept assumes that the river channel and the flood plain are one unit and the flood plain is really a part of the river channel which is used to transmit water only in frequently. The outer limits are taken to be the estimated boundaries of the largest flood to be expected. The degree of hazard decreases away from the river channel and three zones are defined, each with its own group of regulations and its own special set of planning devices to take account of this variability of hazard. This is shown in the figure below:



The 'prohibitive zone' extends from the mid point of the river for some distance on to the plain on either side of the river and is termed prohibitive where, in general, new building development would be prohibited. This area is hydrologically the essential flood way of the design flood, and should be kept free from any encroachment which would reduce the waterway. In such areas, only agricultural or recreational facilities should be allowed. In the second flood zone termed "restrictive", the flood hazard is less. This is known as the flood fringe zone and does not contribute substantially to downstream movement and is covered by water moving only very slowly. Though it is not necessary to prohibit building activities in this zone, developments are still to be regulated to prevent excessive flood damage. The third zone is the "warning zone" and it extends from the limits of the design flood zone to embrace the area covered by the largest flood likely to occur in the region. Flooding in this zone will be extremely rare, but is not altogether improbable. The established developers are warned of the flood risk and, if desired, the safe flood heights and other possible building precautions are supplied to these entrepreneurs.

Land use regulations can be applied effectively only by State and community actions. So regulation of flood plain occupancy is done through statutes, zoning ordinances, building codes, subdivision regulations, government purchase of property and relocation. In some countries, local authorities have enacted such regulation of land, but from experience it has been found necessary for the Government to make this type of adjustment effective. This is due to the fact that local authorities generally hesitate to initiate such regulations for fear of losing profitable activities to other areas as well as not to displease the vested interests. Therefore, intervention by Government to enforce such regulation of land use helps.

Regulation of land use encourages careful assessment of the costs against the benefits of flood plain occupancy. It compels consideration of the relative merits of being in the flood plain as against location elsewhere and offers a valuable complement to other types of adjustment such as flood proofing, flood warning etc. The regulating aspects of flood plain management programmes are sensitive to political pressures for change in favour of individuals. But they can be effective when equitably enforced at all government levels.

Although land use regulation is one of the main adjustments to the flood hazard, its potential role as the most important adjustment is only now being realised even in foreign countries. This is not due to any failure to recognize its advantages which are clear and relate primarily to a balance between land use and the estimated flood risk so that optimum flood plain occupancy is achieved. The main problems relate to the fact that it can normally operate only very slowly in an already developed area unless large scale compulsory purchase and redevelopment are carried out. Also, land use regulation is inextricably linked with the politically biased process of planning and by definition, therefore, impinges upon individual liberty and freedom of choice. This means that regulations which impose restrictions on choice must be seen to be fair and soundly based if they are to stand up in court. Accordingly, when an attempt is made to relate land use to risk, the necessary regulations must rest upon sound estimates of flood magnitude and frequency, and on a satisfactory delineation of the flood plain or other flood prone areas.

5.6.2. *Development and redevelopment policies*

Susceptibility to flood damage can be modified by certain actions other than regulations and statutes by guiding the development in a manner that takes account of the flood hazard and the natural characteristics of the flood plains. Such actions may be taken at the local, State and Central levels through the design and location of utilities and services through policies of open space acquisition and easement and through redevelopment or permanent evacuation, keeping in view the flood hazard.

Local authorities can exercise discretion in extending roads or sewers and water mains into flood hazard areas. Locating public facilities such as railways, libraries, schools, post offices and other Government buildings away from the flood hazard areas lessens the possibility of flood damages to such buildings and also discourages private development in areas prone to flooding. In some cases, acquisition of land can be made for a specific non-flood related purpose such as for public use. Redevelopment of the flooded area may not be only for renewal of the areas blighted, but should embody the principles of flood plain management. Permanent evacuation like renewal is likely to be less common than the above cited measures except for small isolated sectors. To the extent permitted by Statute, Governmental agencies should provide encouragement for relocation of buildings away from flood ways and perilous flood-prone areas leaving such areas for open space uses. In some instances, permanent evacuation of flood prone areas may be the only economically feasible alternatives.

5.6.3. *Structural changes*

Damage susceptibility can be reduced by undertaking structural changes such as construction of walls of buildings with impervious materials, closure of low level windows, underpinning of buildings, construction of buildings on stilts etc. It is reported that in West Bengal and Assam, land fills have been used in villages to keep houses above flood levels even though agricultural lands nearby are liable to inundation.

Structural change is appropriate only where the flooding is low, the duration of flood is short and where the velocity is low, when the traditional type of flood protection is not feasible, when individuals want to solve this problem by themselves or collective action is not possible and, when a higher degree of protection than that afforded by an existing or proposed flood control project is desired. This method, however, can be undertaken by individuals or by groups. In India, raising of villages above a pre-determined flood level and connecting them to nearby roads or high ground as a means of flood adjustment has been adopted in the eastern districts of UP and in some other States. However, the disadvantage of this method is that it does not afford protection to the agricultural areas around. Besides, in all cases, it may not be possible to connect the raised villages to an all-weather road at an economic cost. In fact, due to this reason, even in UP this method is not being continued. Although structural changes and land elevation tend to encourage persistent human occupancy, they are the means of reducing potential loss and also in placing a part of the burden on the flood plain occupants. Most of the measures are normally more easily and economically provided at the time of construction. Hence the implementation of the required design standards should be enforced through building codes.

5.6.4. *Flood proofing*

Flood proofing is essentially a combination of structural change and emergency action though it does not involve evacuation. Certain measures that can be put into action as soon as a flood warning is received are: installation of removeable covers such as steel or aluminium bulk heads over doors or windows, permanent closure of low level windows or other openings, water proofing of interiors, keeping store counters on wheels, closing of sewer well, anchoring machinery, covering machines with plastic sheets, seepage control etc.

Flood proofing also tends to encourage persistent human occupancy of flood plains, but like any structural change it does place the responsibility for taking action on the shoulders of the flood plain occupants. It may be permanent or may be contingent on some action at the time of flood. So they can be classified as permanent measures which become integral parts of the structures or stand-by measures which are used only during floods but made ready for use prior to the flood, or emergency measures which are carried out during a flood according to a predetermined plan.

5.6.5. *Disaster preparedness and response planning*

These are plans made in advance for disaster mitigation, warning, emergency operations, rehabilitation and recovery. These plans will involve activities such as training, post disaster evaluations, review and coordination of Central, State and local disaster preparedness programmes and research. Recovery planning includes long range as well as immediate recovery programmes.

5.6.6. *Flood forecasting and flood warning*

The system of flood forecasting consists of observation and collection of hydrometeorological data at base stations and transmitting them to forecasting centres, assimilation of data from various sources, formulation of forecasts, and their dissemination. These forecasts about floods in advance, allow time for taking precautions and alerting flood fighting organisations, so that timely and appropriate action can be taken. The effectiveness of flood warnings depends upon the effectiveness of their dissemination to the public, the time available, and the action taken in response. Local officials, police, fire and rescue squads, and radio and TV stations should be notified. It is essential to have a proper plan for emergency action. In many cases, contingency and emergency flood proofing and the removal of goods and inhabitants are possible with sufficient warning. However flash floods may permit only the evacuation of inhabitants.

5.7. Modifying the loss burden

The third approach to flood management is to modify the incidence of the loss burden. This is actually a strategy for mitigating the losses by means of actions designed to assist the individual and the community in the preparatory, survival and recovery phase of floods. This category comprises (i) emergency measures and (ii) redistribution of losses.

5.7.1. *Emergency measures*

Engineers are usually careful to state the limitations of the flood control works they design and construct. But those who receive the protection afforded by these works often feel that the protected area will never be flooded again. Therefore, great disasters can result unless positive plans are made to take the necessary action during flood emergency. These emergency actions for the prevention or reduction of the damages and the saving of time are required where there are flood protection works as well as in areas where there are none. The actions which should be taken should be carefully planned in advance so that they may be taken promptly when an emergency arises.

Emergency action consists mainly of (a) evacuation, (b) flood fighting, (c) public health measures.

(a) *Evacuation*

Some communities have come to rely almost exclusively on this form of action. Each year when flood waters begin to rise, they make preparations to evacuate the area; sometimes the actual evacuation is undertaken by the individuals themselves. But generally the local authorities or the Government assumes responsibility for the overall organisation. Organised evacuation by Government authorities is reported along the lower Mekong, the Indus and the Mississippi. With an efficient flood forecasting system, floods can be predicted some time in advance and the population warned. But even with advance warning, the extent of some floods may be so great that evacuation may have to be done during a flood and following it. Flash floods on small rivers and streams also make prior evacuation difficult and complicate the operation due to the need for haste. The solutions to orderly and efficient evacuation are organisation and advance planning.

(b) *Flood fighting*

Efforts to reduce the impact of floods are usually termed flood fighting. Flood fighting in respect of flood control works during a flood are: (i) the operation of existing flood control works, (ii) repair, strengthening and raising of flood control works and (iii) the building of emergency works. Flood fighting will cover building temporary dykes along the river, dowel bunds on the banks, closing small breaches immediately they are noticed, attending to scour, wave wash, sand boils, sloughs etc., evacuating goods and equipment out of the reach of flood waters; protecting equipment with plastic sheets or grease etc., also can be considered as flood fighting measures. Flood fighting is usually planned in advance and all the necessary material and equipment are kept ready before the onset of floods.

(c) *Public health measures*

Floods cause actual physical destruction in addition to putting out of operation of such vital public health associated facility as water purification and sewage treatment plants and pipelines. This results in sickness and loss of life, sometimes on a large scale. The inundation and deterioration of the quality of food grains, the destruction of agricultural crops and death of livestock may lead to famine or at least nutritional deficiencies. When the flood water recedes, stagnant pools encourage breeding of malaria vectors and infectious diseases become common. Therefore, public health teams should be formed in advance so that they will be able to move immediately on a comprehensive public health programme. Necessary supplies and equipment should be available. The public health operation which should be drawn up prior to a disaster should include liaison with other organisations engaged in disaster relief, procedure for immediate mobilisation of personnel and equipment, emergency action to control or eliminate environmental health hazards, emergency restoration of water supply, wastes disposal, provision of advice on remedial measures for damaged sanitary installations etc.

5.7.2. *Radistribution of losses*

This approach to flood management is to modify the burden by spreading is over a larger segment of the community than that immediately affected or by spreading it more evenly over time. The common methods are disaster relief, tax remission and flood insurance.

(a) *Disaster relief*

This measure is for relieving the distress of the flood victims and is the announcement of financial and other aid. In some countries, there are permanent funds established for this purpose and relief may take the form of outright grants, low interest loans and subsidies. At the international level, the United Nations Disaster Relief Co-ordinator has a fund from which money can be drawn to assist victims of disastrous floods or other natural hazards. Very often, aid for flood victims is provided on an ad-hoc basis either by Government or by various voluntary organisations such as the Red Cross. Relief measures of this type help to ease the immediate distress and to aid in the initial rehabilitation. If generous, this may encourage human occupancy of flood plain.

(b) *Tax remission*

The remission of taxes that an individual has to pay is another means of reducing the burden on him.

(c) *Flood insurance*

Flood insurance has several advantages as a means of modifying the loss burden. It enables an individual property owner to spread an uncertain, but potentially large loss, uniformly over a long period of time. It is somewhat similar to automobile insurance in the sense that the average annual premiums are paid to avoid an uncertain but possibly catastrophic loss. Insurance does not reduce the flood loss potential. It simply provides a mechanism for spreading it over time, area and a large number of individuals. It has advantages for both the public and the government. It places part of the burden on those who enjoy the benefit of flood plain location as well as the losses that are associated with the latter rather than making it the responsibility of the public at large.

So far, flood insurance has been adopted only to a small extent in some parts of the world. The private insurance industry has been generally unwilling to enter this field. If uniform rates were charged, a company would find itself burdened with an adverse selection of risks because people only in the highly flood-prone areas are the ones most likely to take a policy. On the other hand, if an attempt were made to charge rates proportionate to the risk, the premia would be much higher than the property owners would be willing to pay. The insurance

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ndustry has also pointed out that even though t is possible to estimate flood frequencies, it is possible that a given insurance company might have to pay out claims for several years in succession. This might result in the company going bankrupt. The only way of surmounting this problem would be for several companies to join hands in providing flood insurance or for the Government to underwrite the claims. Another difficulty in connection with flood insurance is the assembling of the basic data for fair and equitable premiums for areas of varying flood risks. The cost of administering such a scheme is, therefore, likely to be very high. In spite of these difficulties, insurance companies in several European countries have policies covering losses from floods. In Hungary, a scheme has been in operation since 1968 covering losses in the agricultural sector. Recently, a scheme has been instituted in the USA with the Federal Government providing a subsidy to the insurance industry, insisting that its applicability be contingent upon the adoption of land use regulation and other measures to reduce flood damage potential.

The advantages of this measure are that only those activities that can afford to pay the requisite premia can continue occupation. Further, insurance requirements in mortgage agreements can become a factor in stimulating the adoption of flood proofing measures.

5.8. Bearing the loss living with floods

The most common adjustment to the flood hazard in both flood plains and coastal areas is simply to suffer and bear the losses when they occur. This is essentially the response in areas where there is constraint of funds to do anything else or there is no alternative response. In some quarters, there is a feeling that it would be better to bear the occasional loss rather than go in for very expensive flood protection measures. With the growing emphasis on assessing all types of responses to the flood hazard in benefit-cost terms, in many cases, bearing the loss may be the cheapest of the range of possible adjustments, especially as far as the expenditure of public money is concerned.

In developed countries, the experience of being flooded usually results in taking up some adjustments which are meant to offset future losses. Recently, in the developing countries also, the rising needs for food crops and the increasing impact of flood losses on the economy have brought into focus the need for reduction of such losses. It is now-a-days possible to reduce such losses without much cost by the proper management of flood plains. This and other factors indicate that this approach of living with floods is gradually being abandoned and other types of adjustments are being considered.

5.9. Range of choice

A wide range of possible responses to the flood hazard has been discussed in some detail in the foregoing paragraphs. This is also depicted in the chart at Annexure 5.1. In a given situation, however, the effective practical range of choice is likely to be quite limited. Although each of the adjustments may be theoretically available for application, it may not in practice represent a realistic choice. Again, certain solutions may be politically unacceptable while some others ruled out by physical conditions. It is also necessary to stress that these possible adjustments are by no means mutually exclusive. In fact, a combination of alternatives will often provide the most economically attractive solution.

In some countries, flood protection has been chosen at an early stage of adjustment. In such cases, the attention seems to have been deflected from other potential adjustments which might be even more effective or which might act as useful complements to flood control measures. There are signs, however, that the approach to flood management is tending to broaden in many parts of the world owing to the spread of new ideas about water management, the development of new technologies and the refinements of techniques of evaluation; the trend is away from structural measures of flood control to consideration of measures to distribute losses, to alter flood plain use etc. In its broadest sense, the move is in the direction of carefully weighing each possible adjustment and then selecting whatever combination seems best to contribute to regional or national goals. If the goal is the promotion of maximum net return from investment, a particular adjustment will be selected against that which may involve incommensurately large expenditure. But where flood protection is the main adjustment considered, the question to be considered is whether the extent of loss prevented is sufficient to justify the expenditure. Other issues considered now-a-days are whether the net returns from using the flood-prone area warrant the public expenditure including flood protection to develop it and whether there are any other ways in which the losses might be reduced without controlling the floods.

VI. PAST APPROACH AND ACHIEVEMENTS

6.1. Period prior to 1954

6.1.1. *Introduction*

Efforts to mitigate damages from floods originated from the basic human urge for self-preservation. With development of society and civilisation, these efforts of a community, in a cumulative manner, initiated the first human enterprises on flood protection work. Almost all the civilisations which flourished over the fertile river valleys of the ancient world, have left behind accounts and legends of impressive flood protection works. These ancient flood protection works were mostly embankments, with some instances of channel improvements. These embankments came into being under a gradual process of strengthening and integrating field ridges and property boundaries, the process stretching over a number of years. Embankment, as a flood protection measure, was the most obvious solution for preventing damages from spill and was entirely suited to the technology and resources of those days. It had the further advantage that it bestowed benefits to the same local community who had to bear its cost by providing lands and possibly labour, for its inception and thus, more acceptable to the community where the work was to be done. Hence it is no wonder, that the long story of flood protection by construction of embankment, echo back from the dawn of civilisation, developing independently in the ancient lands of Egypt, China and India, right upto the present days.

6.1.2. *Flood protection embankments in India.*

Centuries ago, flood protection embankments were extensively constructed in the Godavari, Krishna and Kavery deltas of the South, some of which are still existing and rendering useful service to the community. In the north, particularly in the Indo-Gangetic plains remnants of ancient embankments recount our long heritage of flood protection technology over the ages. Prosperity and potentiality to yield revenue, were so closely related with proper maintenance of these embankments and construction of new ones, that all rulers with foresight, right from the ancient times, paid a special attention to these, either directly or through their local representatives. During the later part of the British rule, there were impressive lengths of Government-owned and private embankments in many of the States of modern India. Records of all these flood protection works are not readily available, but whatever is available indicate that in the traditionally flood affected States of Bengal, Bihar and Orissa in the north, and the Andhra Pradesh deltas in the south flood protection by embankments was an established practice.

6.1.3. *Embankments before* 1947

At the time of attaining Independence in 1947, there were 120 km. of embankment along the river Damodar and another 3,500 km. of embankment along various channels in the Gangetic delta of the Sundarbans in West Bengal. In Orissa, there were, in stretches, 1,209 km. of embankment along the Mahanadi, 287 km. along the Brahmani and 160 km. along the Baitarni. In Bihar, there were 160 km. of embankment along both banks of the Gandak and embankments in stretches along Ganga and other rivers. In Andhra Pradesh, there were 128 km. of embankment along the Godavari and 120 km. of embankment along the Krishna. In Assam there were 11 km. of embankment along the Brahmaputra near Jorhat and other embankments in stretches, along smaller rivers like the Buridehing, the Desang, the Dikhow and the Bhogdoi. In Tamil Nadu, there were embankments along the Kaveri. In a pamphlet published by Central Water Commission in February, 1977, it has been sammarised that upto independence (1947) about 5,280 km. of embankments existed along different rivers, giving protection against floods to about 3 million ha.

6.1.4. *Embankments upto* 1954

The outlay on flood control during the period between Independence in 1947 and the commencement of the First Plan in 1951 is not readily available. The total outlay on flood protection during the first three years of the first plan, that is during the period 1951—54 works out to only Rs. 1.4 crores. The achievement during this period was construction of some 456 km. of embankments along the Ganga, the Burhi Gandak and other rivers in Bihar, about 60 km. along the Brahmaputra and 140 km. along other rivers in Assam during this period. The details of achievements in other States are not readily available.

The total length of embankments at the time of enunciation of the comprehensive national policy in 1954 may thus be assessed as 6,000 km. giving protection to more than 3 million ha. Some of these protected areas have since been amalgamated in the areas protected since 1954, due to subsequent projects of strengthening the earlier works or due to over lapping, details of which are not readily available.

6.1.5. *First Plan approach:*

In addition to the traditional method of embankments, the technique of flood protection by moderation through flood space in multi-purpose reservoirs, was also adopted for the first time during the period between 1947 and 1954. The chronic sufferings caused due to the recurring floods in the Damodar and the Mahanadi were to be resolved by multi-purpose projects for irrigation, generation of hydro-electricity and flood protection; this was decided as a policy, even before the finalisation of the First Plan. The buoyant and confident approach of Independent India, during its historic commencement of planned development, towards the age-old problems of flood, in departure from the traditional embankments, is reflected in the First Five Year Plan document published in 1952, which summarised that "the problem of flood control is now always considered in conjunction with the construction of multi-purpose, projects. The construction of large dams to store these flood waters is the most effective way of preventing flood damage."

6.1.6. *Reappraisal of First Plan approach:*

Simultaneous to the inception of the multi-purpose projects in the Damodar and the Mahanadi valleys, the flood problem in the Kosi in Bihar, was also receiving attention of the Government of India, and investigations for a multi-purpose dam in Nepal were undertaken. A preliminary project report for this multi-purpose high dam project on the Kosi at Barakshetra was ready in 1950. However, on account of certain technical and other difficulties, a programme for providing flood protection and other benefits in the Kosi basin was conceived in 1953, in which the traditional embankments were again given a key role for the purpose of ameliorating the immediate problems of flood in the Kosi basin. This was a departure from the policy brought out in the First Plan document Published in 1952.

6.1.7. In retrospect, it can be summarised that even prior to the enunciation of the national comprehensive policy on flood protection in the Year 1954, the limitations of the age-old traditional approach of providing flood protection through embankments was realised, and was already supplemented by the concept of flood moderation through storage reservoirs. On the other hand, the need of rendering immediate flood protection to the Kosi basin, indicated that for resolving problems needing urgent solution, in spite of the know-how of the latest flood moderation technology being available, the less sophisticated technology of embankments, may at times, have to be adopted, atleast as a stop gap arrangement for providing interim protection. The Policy announcement of 1954, which was a considerable departure from the categorically advocated approach in the First Plan document published only a couple of years earlier, was obviously a pragmatic reappraisal of the situation prevailing in the country with regard to the technological feasibility, status position of the formulation and time and resource requirements for implementation of different types of measures, coupled with the urgency of giving protection despite limitations of resources.

6.2. **National Policy on flood problems and remedies**

6.2.1. *The initial Policy Statement in* 1954.

During the monsoon of 1954, when there was a spate of severe floods, the Union Minister for Planning and Irrigation & Power, placed before the Parliament on 3rd September, 1954, two statements regarding 'Floods in India—Problems and remedies'. and 'The Floods in the country'. These Statements enunciated for the first time the national policy regarding the problems of floods and the remedies in a comprehensive manner. Copy of the former appears as Annexure 6.1 and of the latter as Appendix VI of Vol. II.

6.2.2. *Background and objectives:*

(i) *Background*

In the policy Statements, it was indicated that although floods had been causing serious damage to the property and inflicting hardship on the people, no systematic attempt had been made so far to devise adequate measures for flood protection in areas so affected. It had been opined that the Nation was facing a tremendous problem, the solution of which could not brook any delay. The policy statements manifested an intense desire to ease the hardship and mitigate damages caused by floods. The policy had also been formulated with the background of an objective appraisal that in the past, there was lack of sustained and systematic efforts to deal with the problem on a comprehensive basis. It was also stated that although Flood Committees had been appointed from time to time by the various States, their recommendations had, for the most part, remained a dead letter. This twin awareness that the solution of the flood problem could not brook further delay and that no systematic attempt had so far been made to devise adequate measures, can be taken to be the main background for the enunciation of the comprehensive policy on flood problem and remedies.

(ii) *Initially set objectives*

The objective that had been set before the nation in the policy enunciation of 1954 was manifestly optimistic, the spirit of which can best be expressed by the following extract from the conclusion to the Statement:

> "I may in the conclusion express the conviction that floods in the country can be contained and managed, and that the problem is capable of solution. It is obvious, however, that a programme of flood control on a scale visualised cannot be completed in a short time unless the energy of the people and the resources of the Nation are mobilised effectively on a large scale. The administration and the people have both to share the responsibility and undertake tasks of a huge magnitude in order that the country may be rid of the menace of floods".

The objective unequivocally set, in the initial policy statements, was to rid the country from the menace of floods by containing and managing floods and thus solve the problem.

(iii) *Subsequent reappraisals of the objective*

The above mentioned optimistic objective had, however, undergone gradual reappraisals in subsequent years. In the 'Supplementary Statement on the flood situation and the flood control programme' by the Minister for Planning and Irrigation & Power, placed before the Parliament on the 27th July, 1956, the above optimistic note changed a little, perhaps due to the factual position of the achievements during the two years following the initial policy enunciation, as would be evident from the following extract:

> "In the end I may point out humbly that while a progressively increasing measure of protection from floods would be achieved each year, we cannot expect for years to come to be in the fortunate position of being absolutely immune from flood risks. We shall have to learn to live with floods to an extent".

The above extract indicates that although the objective about eventual absolute immunity from flood risks does not seem to have been given up, the programme of its implementation had been reappraised. However, this reappraisal of the programme of providing absolute immunity from flood risk is followed by an optimistic reiteration in the same Statement about the ultimate objective as extracted below:

> "We shall, however, be able to curb and confine the floods, more and more and do all that is possible to save ourselves from the harm and the devastation that they bring".

Simultaneous to the aforecited Supplementary Statement, a statement on the flood situation and flood control programme was laid by the Union Minister of Planning and Irrigation and Power before the Parliament on 27th July, 1956. In this Statement, it was, however, pointed out that absolute immunity from flood damage was not physically possible even in the distant future, because of the unpredictability of several natural forces which might cause unprecedented situation. The subsequent logical step towards the concept of modifying susceptibility to flood damage was, however, introduced in the objective somewhat later.

The report of the High Level Committee on Floods 1957, indicated the necessity of a new thinking on the ultimate nature of the problem regarding providing flood protection. The Central Flood Control Board, in its 7th meeting held in May, 1958, under the Chairmanship of the Union Minister in charge of Planning, Irrigation and Power who was also incharge of Flood Control, noted the vital recommendation of the High Level Committee that absolute or permanent immunity from flood damage was not physically attainable by known methods of flood control and hence, flood plain zoning, flood forecasting and warning and like measures should, therefore, be given due importance. This new consciousness about the limitation of known methods of flood protection was reflected in the subsequent Statements presented to the Parliament.

The "Statement on the flood control programme and the flood situation in the country" laid by the Minister, Irrigation and Power, before the Lok Sabha on the 28th August, 1958, indicated a tangible amendment of the initial objective for the remedial measures for solving the flood problem, as given under the paragraph on ultimate nature of the problem as extracted below:

> "The various flood control measures either executed or visualised should not lead to a wrong impression that complete immunity from flood damage is physically possible in some distant future. Any such illusion has to be dispelled and it has to be emphasised again, as it has been emphasised in the past in the Statements laid on the Table of the House from time to time, that even the best known methods of flood control aim only at providing what may be called a reasonable degree of protection so as to facilitate full time occupancy of land and structures that would otherwise be subject to damage. Complete protection even if

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> technically feasible would not be economically justifiable in all areas and in all communities.
>
> There is, however, every hope that, with the completion of the immediate, short term and long-term programmes, there will be substantial diminution in human distress and sufferings due to floods".

The above extract would show that the initially set objective of getting rid of the menace of floods, containing and managing floods and thus solving the flood problem, had since undergone a tangible modification, due to a pragmatic awareness that the known methods of flood control aim only at providing a "reasonable" degree of protection against floods.

The policy statement in the initial stages, did not lay stress on the objective of achieving reduction in flood damages by adjustment of activities that would be adversely affected by floods.

6.2.3. *Implementation and resource responsibilities*

(i) *Implemention approach*

The subject of flood is considered basically to be the responsibility of the concerned States. In this background, the policy enunciation on national comprehensive approach towards flood protection, quite understandably, indicated that the implementation of the phased programme of providing flood protection was to be done by the concerned States. However, the role of the Central Government was intended to be equally vital, as will be clear from the following extract from the policy statement:

> "The State Governments are primarily responsible for the execution of projects for the control of floods in their area. As many of the major rivers of India pass through more than one State, the control of floods is an inter-State rather than a State problem. Denudation of forests by reckless exploitation in States where the headwaters lie may expose a state in the lower reaches to devastating floods and yet the State affected would be helpless in taking remedial action. Furthermore, the financial resources of States may not always be adequate for undertaking major flood control works. It is, therefore, obvious that unless the Centre takes the initiative in this matter and helps the State Government to formulate and if necessary implement a systematic plan of flood control, no tangible progress is likely to be achieved in this direction."

With regard to the implementation of the flood control programme outlined in the policy statements, the overall responsibility was to be vested in two tier Boards at the Centre and the State levels. The responsibilities proposed to be given to the State Flood Control Boards were to assess the flood problem in their areas and to (a) collect data, (b) prepare a comprehensive flood control scheme for the State, (c) indicate priorities, and (d) ensure the implementation of the approved schemes. The Central Board was to be assisted by a Steering Technical Committee consisting of experts in flood engineering, soil conservation and agriculture. Subsequently, four River Commissions, namely the Ganga, the Brahmputra, the North West and the Central India River Commissions were also set up, mainly with the purpose of preparation of intergrated plans of the river basins and ancillary matters.

The above functions of the Boards were modified to a certain extent, as per recommendations of the December, 1957 report of the High Level Committee on Floods, approved in the 7th meeting of the Central Flood Control Board on 12th May, 1958. The overall modified responsibilities were as under:

A. **Central Flood Control Board:**

(i) To lay down the general principles and policies in connection with floods and flood control measures.

(ii) To consider and approve the Master Plans for flood control as submitted by the States or River Commissions.

(iii) To consider and approve specific schemes of flood control works submitted to them for approval.

(iv) To arrange for necessary assistance in connection with investigation, planning and execution of flood control works.

B. **State Flood Control Boards:**

(i) To approve the long-range plans and specific schemes for flood control measures and their priorities.

(ii) To assess the flood problem in the State to deal with question of policy in connection with flood, flood relief and measures for flood control and protection.

(iii) To consider and approve of the arrangements and programme for carrying out surveys, investigations and collection of data for flood control works.

(iv) To watch the progress of implementation of the approved schemes and to issue suitable directives to the department concerned.

(v) To approve of measures proposed for coping with emergent situation.

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(vi) To examine and approve of the proposals for an effective flood warning system for the State.

(vii) To give such other directions to the departments concerned as may be considered necessary in regard to flood problems.

(ii) *Resource responsibility*

The help to be given by the Centre to the States was broadly covered in the initial policy Statement, advocating quite forcefully about more of Central participation vide the extract already quoted in para 6.2.3.

6.2.4. *Initial Strategy for Amelioration*

(i) The realisation that the solution of the tremendous problem of floods in the country cannot brook any delay, dictated the strategy for amelioration, that is the choice of the nature of remedial measures, as indicated in the initial policy statements of September, 1954. The statements covered a number of possible alternatives and then outlined a programme for securing a large measure of protection from flood hazards in the vulnerable areas.

The initial Policy Statements indicated the aggravation of the flood problem of the Himalayan rivers by deforestation in the upper catchment area and consequent soil erosion and silting of beds of rivers, resulting in shifting of their courses and recommended that this particular aspect must receive much more attention than before. These statements cited the proposed protection from floods in the rivers Damodar and Mahanadi by construction of multi-purpose storage reservoirs and opined that such reservoirs, wherever feasible, were obviously amongst the most effective measures for the control of floods. They also referred to other multi-purpose dams under construction or contemplated, which would provide protection from floods to a certain extent, although flood control was not the dominant consideration in their concept. However, it was concluded that while on the one hand, an adequate programme of storage works in relation to all the areas which were liable to floods had to be thought of mostly as a part of the long-term development of the country, the urgency of the need for flood protection on the other hand, indicated the inevitability of the adoption of the methods which could be carried out expeditiously. The Statements also acknowledged that in the past years there was lack of sustained and systematic effort to deal with flood problems and there was unfortunate neglect in respect of collection of hydrological and other data without which no remedial measures of a reliable character could be devised.

(ii) *Outline of phased programme:*

After discussing the above background, the outline of the programme and nature of the remedial action, as summarized in the initial Statements of September, 1954, were as under:

> "*Immediate*—The first phase will extend over a period of two years. This period will be devoted to intensive investigation and collection of data. Comprehensive plans will also be drawn up and designs and estimates prepared for short-term measures of flood protection. Some measures such as revetments, construction of spurs and even embankments may be applied immediately in selected sites.
>
> *Short-term*—During the second phase, which may be taken to start with the second year and would extend to the sixth or the seventh year, flood control measures, such as embankments and channel improvements, will be undertaken. This type of protection will be applicable to a major portion of the areas now subject to floods.
>
> *Long-term*—The third phase will relate to selected long-term measures such as the construction of storage reservoirs on tributaries of certain rivers and additional embankments, wherever necessary. This may take 3 to 5 years more".

(iii) *Alternative measures*

In the paragraph on 'Resume for the period prior to 1954' the technological development within the country, forming the background to the adoption of the above outline of programme for providing flood protection has been discussed. The enunciation of the above extracted outline of the programme and recourse to particular measures, were, however, preceded by a list and appraisal of the suitability of the following possible lines of remedial measures:

"1. Embankments where feasible to keep the flood out of areas which are otherwise subject to inundation.

2. Storage reservoirs, preferably on the tributaries.

3. Detention basins where the excess of flood water may be stored for a short while.

4. Diversion of water of one river into the other.

5. Increasing the slope of the river by cutting down loops.

6. Dredging and channelling portion of the river where waterway has been reduced due to silting.

> Besides these, some other measures like revetments and spurs will be necessary to safeguard any particular town exposed to danger of being eroded."

It was also visualised that after collection of the requisite data, the choice of appropriate method of combination of methods could be made and each case would have to be considered on merits and a measure or a combination of measures adopted, if a proper solution was to be found.

The policy Statement laid stress on the preparation of comprehensive flood control schemes for each of the States which were liable to frequent floods. The role of soil conservation and agriculture was also recognised, and the experts on these were to assist the Central Flood Control Board entrusted with the preparation of the national flood control programme.

(iv) *Creation of employment opportunity influencing the choice*.

The possibility of mobilising public participation and scope of providing broad based employment opportunities, also seems to have been a criterion favouring the choice of embankment as the predominant measure for providing flood protection, as can be seen from the following extract from the policy statement:

> "Although embankments do not provide absolute immunity from the floods they will ensure a very large measure of protection, which, given, good maintenance, should prove to be a lasting character. Provided the enthusiasm of the people can be aroused, as it is stated to have been in China, and their cooperation secured for this work of national importance, it would be possible to complete the embankment in about 7 years if a start is made immediately. The programme of flood protection work will incidentally provide on a tremendous scale opportunities for employment of a simple character, scattered over large areas."

(v) *Summary of outline programme*

The time schedule and the adoption of type of flood protection as per the outline of the phased programme in the initial policy statements of September, 1954, can briefly be summarized as below:

(i) *Immediate phase* (till the end of 2nd year)

(a) Embankments at selected sites.

(b) Revetment and spurs, as a measure to protect towns against river erosion.

(c) Intensive collection of data, investigation and preparation of comprehensive plans and designs and estimates of projects of short term phase.

(ii) *Short-term phase* (from 3rd to 7th year)

(a) Embankments.

(b) Channel improvements.

(iii) *Long-term phase* (from 8th to 12th year)

(a) construction of selected storage reservoirs on tributaries of certain rivers.

(b) Additional embankments wherever necessary.

(iv) *Beyond long-term phases* (after 12th year)

(a) Other long-term measures.

(vi) *Interse priorities in the programmes*.

It seems obvious that the long period needed for collection of data, which was to be collected from almost scratch, was one of the reasons for deferring commencement of reservoirs on tributaries to the 8th year after the initial policy enunciation. Investment requirements as already discussed, and the time needed for implementation were the other factors which deferred the programme of reservoirs.

6.2.5. *Subsequent additions*

(i) *Flood warning and watershed management*

While discussing the progress on ancillary measures; the Statement placed before the Parliament on 4th April, 1955, indicated that flood damages, pertaining specially to loss of life and cattle, could be minimised, if timely warning was given of the incoming floods, and in this context, steps taken for importing automatic flood warning sets was intimated to the House. In this Statement, it was also indicated that the role of soil conservation and watershed management was being recognised increasingly as an essential adjunct to any scheme of flood protection and in this context, the House was informed about preparation of a few experimental schemes on some kholas (hilly streams) in the Kosi catchment and that with the experience gained on this work, works on other Kholas would be continued.

(ii) *Inclusion of drainage under flood control programme*:

In the Statement on the flood situation and the flood control by the Minister, Planning and Irrigation & Power, placed before the Parliament on 31st July, 1956, while discussing importance of drainage, it was opined that efficient drainage systems including channel improvements will have to be planned to ameliorate the immense damage caused by local precipitation in flat areas with inadequate natural drainage.

(iii) *The High Level Committee* 1957

Although the policy statement of September, 1954, broadly indicated the outline of the strategy to be adopted for providing flood protection in a phased manner, over a period of more than a decade, the Government of India wanted a review of the same, only a couple of years after the enunciation. A reference to the background of this decision was given on 12th December, 1956, in the oral statement given by the Union Minister of Irrigation and Power as extracted below:

> "The flood problem is so varied and intricate in nature that it is desirable to secure authoritative advice in regard to the works to be undertaken hereafter. Opinion is sharply divided on the suitability of certain measures of flood protection in shape of embankment. It is important that all such questions should be settled beyond doubt. The Government, therefore, propose to set up a high level committee".

A formal decision to constitute a High Level Committee on floods was taken in February, 1957. The terms of reference to this Committee mostly related to the policy on the strategy to provide flood control. The High Level Committee submitted its report in December, 1957, and this was considered by the Central Flood Control Board in its seventh meeting held in May, 1958. Some of the important recommendations of the Committee relating to the strategy for flood protection, which were either noted or approved by the Board, are extracted from the proceedings of the seventh meeting of the Board as under:

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(i) Absolute or permanent immunity from flood damage is not physically attainable by known methods of flood control. Flood plain zoning flood forecasting and warning, and like measures should, therefore, be given due importance, particularly as these do not require large capital investment.

(ii) Flood control schemes should fit in with plan for other water resource developments such as irrigation, power, domestic water supply, etc. to the extent feasible.

(iii) In considering future plans, the flood control aspect of a multi-purpose project should be considered simultaneously with other aspects.

(iv) when a delta is extending rapidly, the lower reaches of the river should not be embanked as otherwise the raising flood levels would perpetuate the problem of drainage and water logging in the adjoining areas. Similarly, premature embanking of freshly formed lands at the deltas must be avoided.

(v) Proposals for constructing flood embankments which State Governments may have in view for inclusion in the third and subsequent Five Year Plans, should be studied in detail to determine their effect on the river basin before these schemes are accepted for inclusion in the Plan.

(vi) In general, embankments are satisfactory means of flood protection when properly designed, satisfactorily executed and adequately maintained in localities where construction of embankments is technically indicated but a suitable combination of this method with other methods such as storage dams, detention basin, etc. is usually more efficient and should be adopted as resources permit.

(vii) When it is not economically possible to preclude floods in certain areas, raising of habitations or other important places may be resorted to in order to prevent damage to property and inconvenience to inhabitants.

(viii) Priorities for soil conservation work relating to flood control should be as under:—

(a) Catchment areas of multi-purpose dams;

(b) Himalayas with their foothills;

(c- Indo-Gangetic plain; and

(d) Deccan plateau.

(ix) In order to increase the tempo of soil conservation work relating to flood control, watersheds should be arranged in order of priorities and detailed scheme should be prepared for such works which require immediate treatment. Work commenced in a catchment should not be left incomplete to take up work in other catchments.

(x) Priorities amongst flood control schemes must be decided by taking an integrated view of the various considerations involved, the human and social aspects receiving its due emphasis. The following order of priority in general is recommended:

(a) Emergent schemes,

(b) Continuing schemes,

(c) Schemes for the protection of important urban and industrial communities.

(d) Schemes which would help in augmenting flood protection in the country.

(e) Schemes which combine other beneficial utilisation of waters.

(iv) *Ministers' Committee on Flood Control* 1964

A Ministers' Committee on Flood Control was constituted in February, 1964, to review and assess the action taken by the Centre and the States in respect of the National Flood Control Policy outlined in 1954. This Committee gave its report in December, 1964, which reiterated some of the recommendations already discussed, and observed and recommended the following important additions or amplifications in the flood protection strategy:

(i) More attention to be paid to the methods of flood control other than embankments like minor, medium and major storages, canalisation, inter-basin diversion and to such non-physical measures like flood warning and forecasting, flood plain zoning and flood insurance.

(ii) The future progress of flood control in the major flood belt in India appears to lie in a close integration with hydro-power schemes.

(iii) Planning and execution of intensive soil conservation land treatment measures, in an integrated manner in catchments producing minor floods. These schemes should lay stress also on engineering measures with a beneficial effect on flood control activities.

(iv) Study of the necessity and possibility for the construction of headwater storage dams, on a multi-purpose basis, in the interests of flood prevention and sediment detention in respect of catchments producing major floods.

(v) Work of flood warning and forecasting should be made an integral part of the functioning of the flood control Departments of the States.

(vi) Taking steps for the preparation of maps of different river basins showing flood zones corresponding to floods of different intensities and frequencies, to widely disseminate such information in the map and to issue administrative orders for restricting the occupancy of zones specified in such maps.

(vii) Evolve realistic insurances schemes providing cover against flood damage.

(v) *Ministers' Committee on Flood and Flood Relief* 1972

In October 1970, a Ministers' Committee on Floods and Flood Relief was constituted to enquire into the heavy loss of lives and property from floods and to draw up suitable proposals for avoidance of such heavy loss of lives etc. in future. This Committee submitted its report in March, 1972, which gave the following further recommendations on the strategy for flood protection:

(i) Even in projects purely for other uses like Irrigation, Power, etc. possibilities of providing additional storage for flood moderation should be examined. Wherever it is not possible to do so, at least the operation schedules should be drawn in such a fashion that optimum use is made of the reservoir capacity for moderating the floods lower down.

(ii) Anti-erosion works, which are costly both in initial construction as well as in subsequent maintenance, should as far as possible be restricted to locations where valuable properties, important lines of communications etc. are in danger.

(iii) Possibility of river diversion and channel improvement should also be investigated in detail along with other measures of flood control.

(iv) In framing the long range comprehensive plan for flood control, each flood affected State should frame programmes of soil conservation after detailed investigations.

(v) Action should be taken by the various State Governments for preparation of maps of the different river basins, demarcating therein the areas where human habitation will have to be restricted by administrative measures.

(vi) Suitable action be taken for preventing encroachments of rivers and natural drainage channels as encroachments reduce the carrying capacity of rivers and natural drainage channels thus giving rise to increased flood heights.

(vi) *Working Group on Flood Control,* 1978

The Central Flood Control Board, in its 16th meeting held at Delhi in November, 1977, decided that since the irrigation, flood control and drainage aspects could not be dealt with in isolation and since in almost all the States, the Ministers in charge of Irrigation were also in charge of flood control, the subject of flood control could be discussed in the State Irrigation Ministers' Conference, with which the Central Flood Control Board might be amalgamated. After the above decision of the Board, the next Irrigation State Ministers' Conference, that is the fourth conference held in February, 1979, at Trivandrum, passed a resolution noting and endorsing the major policies and strategies recommended by the Working Group on Flood Control, set up by the Union Department of

Irrigation. The Final Report of the Working Group on Flood Control, as brought out in November, 1978, by the Ministry of Agriculture & Irrigation, recommended the following important points with regard to the strategy for flood protection:

(i) State Governments should critically examine all major existing works and put up proposals for stabilising existing benefits.

(ii) The work of flood forecasting should be extended to other inter-State rivers and should be continued with added emphasis on modernisation of the systems.

(iii) Flood affected States should prepare basinwise plans in close coordination with Irrigation and other departments. The outline of Master Plan should be finalised by each flood affected States by March, 1980. Detailed Master Plans should be finalised by March, 1982.

(iv) In connection with Flood Plain Regulation and Management, the basic work of detailed surveys and preparation of contour maps should be carried out in the Central Sector. The State Government should demarcate areas liable to floods of different frequencies and intensities both on maps as well as on ground and enforce necessary land use regulation.

(v) While embankments constructed so far have by and large given the desired protection to large areas at comparatively low costs, their consequent long-term effects on river regime are yet to be evaluated. New embankment schemes should be taken up with caution after carrying out detailed studies.

(vi) Anti-erosion works should normally be taken up for protection of town and a group of thickly populated village abadis, railway lines and roads where re-location is not feasible on techno-economic ground and for protection of portions of embankments benefiting large areas where retirement is not possible.

(vii) All storage reservoir projects in the catchments of flood prone rivers should be given priority. All such projects planned for irrigation/power should be reviewed in detail to examine the possibility of providing specific flood storage. Operation schedules should be drawn up so as to provide flood moderation to the extent possible.

(viii) Studies with regard to likely benefits of flood moderation by the proposed reservoir projects in Nepal should be immediately carried out.

(ix) Soil conservation programme would be complimentary to the engineering programme of flood control and should be taken up simultaneously. However, economic justification of this programme will have to come largely from other inherent benefits of such a programme. Experiences of other countries indicate that while these measures do have beneficial effects on reduction of flood peaks of small floods on small catchments, these may not have any significant effect in the reduction of flood peaks in the large damage producing floods. These measures help in reduction of silt in the river.

(vii) *Fourth Conference of State Ministers of Irrigation*, 1979.

The Conference held in February, 1979, passed several resolutions on floods and flood protection. Those relating to important flood control strategy are summarised below:

(i) The work of preparation of Master Plans for flood control and drainage within the framework of the overall development of water resources should be completed within next four years.

(ii) Preparation of detailed contour maps in respect of flood prone areas be expedited by taking up the work in the Central Sector. Steps should be taken to demarcate flood zones corresponding to various flood frequencies and intensities.

(iii) Necessary administrative and legal steps be taken immediately by the concerned authorities to regulate further development activity in the flood plain.

(iv) New embankment schemes should be taken up with caution and detailed studies regarding their effect on the river regime and behaviour made while assessing the costs and benefits.

(v) Anti-erosion works should normally be taken up for protection of towns, industrial areas and a group of thickly populated village abadis, railway lines and roads where relocation is not possible on techno-economic grounds, and for protection of portions of embankments benefiting large areas where retirement is not feasible.

3. Achievements since 1954:

3.1. *Overall achievement*

Flood protection is a benefit, which cannot be ssessed from a physical measurement every ear, as is possible, say in the case of irrigation enefit. The usual method of assessing the nnual benefits from a flood control project is e estimation of the loss which would have ccurred, had there been a design flood, irresective of the magnitude of actual flood during at year. The benefit is usually reported in rms of the area protected, the implied meaning eing that it is the area which in the past would ave been flooded in case of occurrence of the esign flood and which, now, will be protected y the project. On this basis, the overall proected area in the country works out to about million ha. out of which, as already discussed, e protection given upto 1954 was a little above million ha. However because of the possibility f some of these areas having been included in e figures of achievements since 1954, the area rotected so far will for all practical purposes be bout 10 million ha. The Statewise break-up of ese protected areas since 1954 is shown in nnexure 6.3.

The investment in the flood control sector from e commencement of the First Plan to the end f the Fifth Plan is about Rs. 640 crores, the tatewise break-up of which is shown in nnexure 6.2.

3.2. *Review of financial outlays during plans.*

i) *Approach towards financial responsibilities:*

Flood control programme got its individual entity separate from the irrigation programme, ly after the First Plan. While drawing up the irst Plan, flood control works were dealt with roadly as a part of the irrigation programme.

After First Plan, the approach towards the terse responsibility of the Centre *vis-a-vis* the tates for making available the necessary finanal resources for implementation of flood proection programme, had undergone certain egree of changes during different Plans.

It was indicated in the Third Plan document at since at the time of preparation of the Seond Plan, sufficient data had not been collected r preparing detailed proposals for flood conol for inclusion in the Plans for the States, e flood control programme was taken up on an mergency basis, and was, therefore, treated as centrally sponsored programme in the Second lan.

The Third Plan document also indicated that t the time of preparation of the Third Plan, onsiderable progress had been made in surveys nd investigations, and, therefore, flood control rogramme formed a part of the plans of States n the Third Plan.

A Central Sector provision of Rs. 8 crores was ncluded in the Fourth Plan. In the Fifth Plan, nancing was being done under the Central ector for the flood protection projects in the Brahmaputra Valley, the flood control components of Rengali dam in Orissa and anti-sea erosion works in Kerala. The Sixth Plan is yet in draft stage, but the Working Group on Flood Control has recommended a policy of the Centre financing specially selected flood control projects and bearing a larger share of the outlay on flood control programmes. The changes in the approaches are summarised below:

Plan	Mode of financing
First Plan. . . .	As part of Irrigation programme
Second Plan.	Centrally sponsored programme
Third Plan. . . .	As part of State Plan
Fourth Plan . . .	As part of State Plan
Fifth Plan. . . .	As part of State Plan. However, some selected flood protection schemes were sponsored in the Central Sector.
sixth plan.	Working Group recommendations favour enhanced sponsoring from the Central sector.

(ii) *Overall Plan outlays*

The policy enunciation in 1954, made it clear that the first three phases of flood control measures, by themselves, will take 12 years. It was also made clear that during that period only selected measures would be accommodated under the long-term phase, implying thereby that the flood control programme would extend considerably beyond the aforesaid period of 12 years. With such a long implementation period of a programme, the planning of financial allocation would normally be expected to steadily increase in line with the overall size of the successive Plans.

The outlays on the "flood" sector show a progressive rise during the First to Fifth Plan and the proposed outlay during the Sixth Plan. As seen from the following table, this rise in outlays, however, did not follow the pattern of Plan sizes.

Plans	Period.	Outlay on flood protection Rs.crores	Plan site Rs.crores	Percentage column 3 / column 4
1	2	3	4	5
First Plan . .	51—56	13.8	1,960	0.70
Second Plan .	56—61	49.2	4,600	1.07
Third Plan . .	61—66	86.0	8,573	1.00
Annual Plan	66—69	43.6	6,757	0.64
Fourth Plan .	69—74	171.8	15,902	1.08
Fifth Plan . .	74—78	274.9	39,303	0.70
Total :	51—78	639.3	77,095	0.89
Proposed Sixth Plan . .	78—83	763.5	69,380	1.10

(iii) *Overall Plan Outlays*

In contrast to the progressive rise in the outlays in the Flood Sector as shown above, the outlays in some of the States, as detailed in Annexure 6.2, do not show the same trend.

The outlays of Bihar during Second Plan was Rs. 19.7 crores and that during the Third Plan only Rs. 13.7 crores, indicating a reduction of 30.4 percent. Similar was the case of U.P. with a reduction of 13.7 percent. In the Punjab, the outlay during the Fourth Plan was less than that during the Third Plan by 57.5 percent. These declines in investment would have been understandable, had all the feasible measures been at a completion stage. This, however, was not the case as evidenced by the increased outlays in the subsequent Plans. Thus, the decline in outlay was obviously not due to a saturation stage of providing flood protection measures in these States. The overall Plan sizes of all the above-mentioned States have progressively increased from one Plan to the next. Thus, if outlays on flood control are shown as a percentages of the Plan sizes of the States, the variation in these percentages for different Plans would be even more than the percentage variation in the amounts of outlays.

The fluctuations in the Plan outlays for flood protection by different States during successive Plans, indicate that though required in the context of national policy, no consistent policy was followed in the matter of apportionment of available financial resources either in the Central or in the States. This haphazard pattern of outlays cannot be solely due to the shifts in the national policy. Nor can this be ascribed to lack of work as considerable spill-over of the flood control schemes occurred from one Plan to the next and schemes stretching over several Plans were quite common in many of the States. The reasons for such wide fluctuations in the Plan could be adhocism in sectoral priorities, non-availability of investigated projects or fluctuating interests in the matter of floods in flood-free years. Needless to say that only a sustained long term action could help mitigate the flood problem in the country.

6.3.3. *Review of physical achievement since* 1954:

(i) *Overall position*

We had devised specific proformae in our questionnaire to the States, for obtaining detailed informations about their past achievements in physical terms so that the same could be evaluated. The response from some of the States was not satisfactory, so much so that some of the States were unable to give even a comprehensive list of their completed projects. Under these circumstances, there was no option but to depend upon figures available with Central Water Commission. These figures may undergo changes on reconciliation with the States.

The overall physical achievements from 19 to 1978 are 10,821 km of embankments, 19,2 km. of drainage channels and channel improv ments, protection to 264 towns, raising and pr tection of 4,697 villages and many anti-erosi works. The corresponding area protected estimated to be 99.85 lakh ha. Statewi break-up of these achievements are shown f embankments in Annexure 6.4, drainage cha nels and channel improvements in Annexu 6.5, protection to towns in Annexure 6.6, and ra ing and protection to villages in Annexure 6.7.

(ii) *Rate of providing protection*

The rate of progress in providing protecti was not uniform during the period 1954 to 19 The average annual achievement during the 24 years works out to 4.16 lakh ha. The achiev ment during the 10 years from 1954 to 19 works out to be 3.74 lakh ha. per year. The ne 10 years from 1964 to 1974 provided addition benefit to 32.22 lakh ha., the average per ye being 3.22 lakh ha. or only 77 per cent of the ove all average of 4.16 lakh ha. per year. Again this, the achievement during the last 4 yea 1974—78 was 7.57 lakh ha. per year. Duri 1974-75, the achievement was of the order 10.53 lakh ha. during 1975-76 of 4.96 lakh h during 1976-77 of 8.97 lakh ha. and during 1977- of 5.81 lakh ha. Compared to the annual ave age of the 24 years period, the pace of providi additional benefits has been about average duri the first ten years, only 77 percent during t next ten years and 182 percent during the la four years. A significant drop during the 11 to the 20th year, indicates that the overall pla ning did not follow a pattern of gradual accel ration expected in a well-planned programme.

(iii) *Pace of construction*

The pace of construction of embankment w not uniform during the period 1954—78. T overall achievement of 10821 km. in twenty-fo years works out to an annual average of 451 k Against this, the rate during the period 1954— was 434 km. per year, followed by a rate of 397 k per year during the period 1964—74. The achiev ment during 1974—78 again picked up with a average of 627 km. which is 139 per cent of t overall annual average during 1954—78.

The annual pace of completion of drainag channel was 802 km. during 1954—78. The corre ponding annual rates during 1954—64, 1964— and 1974—78, were 394 km. 638 km. and 1985 k respectively. These figures indicate a favourab increase in the pace of achievement with tim expected in a well-chalked out programme.

The number of towns protected during 1954— was 78, during 1964—74, 110 and during 1974— 76. Providing protection to towns also shows favourable increase in the pace of achievement with time.

The number of villages protected by raising r other work was 4336 during 1954—64, 310 dur- ıg 1964—74 and only 51 during 1974—78. It ›ems that Uttar Pradesh which did this work ι 4,500 villages, representing 96 per cent of the verall achievement of 4,697 villages in the ɔuntry, has subsequently stopped this pro- ramme altogether, because their experiences ʼere none too happy about the actual perform- nce of such measures.

The overall physical progress under the four ypes of flood control measures indicate a general ıll in rate of providing protection during the eriod 1964—74 and so was the pace of construc- on of embankments, though there was increas- l pace of construction of drainage channels. 'his goes to show that embankments have, by ır, been the major measure of providing protec- ion. The individual achievement of the States re listed in the Annexures 6.3 through 6.7.

.3.4. *Overall assessment*

Concluding this review of achievement, we ıay recall the outline of the programme enun- iated in 1954 and discussed in paragraph 6.2.4. 'he period of twelve years by which these pro- rammes were to be completed ended as far back s 1966. If we consider our achievements, it will e seen that some of the programme proposed ɔ be completed during the "immediate phase" etween 1954 and 1956 still remains to be com- leted. For example, investigations and pre- ıaration of all projects to be executed in the hort term phase' were to be completed during he 'immediate phase', this has not yet been chieved, and even now we are investigating rojects, which work should have been comple- ɔd much earlier. Statewise and basinwise com- rehensive plans were also to be drawn up, dur- ıg the immediate phase. This has not been one even by now. According to the programme ıid down by the fourth Irrigation Ministers' 'onference, this work is now to be completed y the year 1983.

The initial programme was perhaps too ambi- ious to be implemented within the time frame halked out in the outline, but it also cannot be lenied that there has not been adequate follow ıp of the programmed investigations, collection f data, preparation of projects and estimates, lanning and preparation of Master Plans.

With regard to physical execution of projects, he programme of providing reservoirs in the ributaries, as envisaged in the long-term mea- ures has not yet been taken up. Construction f reservoirs apart, even the investigations work ınd feasibility reports have not been completed, nd in most cases not even commenced. Efforts ıave so far been directed mainly towards the ʼorks in the short-term phase, viz., embankments nd channel improvements, and immediate phase ʼorks of town protection and anti-erosion. Short-term phase works like embankments and channel improvements were to be taken up after preparation of the comprehensive plan; this was, however, not done in some cases.

The overall flood problem of the country was perhaps somewhat under estimated at the time of drawing up the initial outline of the programme. The outlays needed, have obviously not been available, and thus, possibly the emphasis had so far been mainly on short-term and immediate projects. That programme without assured resources, was difficult to accomplish is understandable, but the general apathy towards preparation of comprehensive plans, collection of data and detailed investigations cannot be ignored and has to be remedied effectively.

6.4 Assessment of performance

6.4.1. The types of flood management works so far adopted have been mainly embankments, channel improvements and construction of drainage channels, town protection works, raising of villages and flood moderation reservoirs. Measures like detention basins, emergency floodways, inter-basin transfer ond watershed management have been tried on a very limited scale and no assessment of the performance of these could be made. Measures like weather modification, flood damage insurance, flood plain zoning and land use regulation have not yet been brought into operation, thus, there could be no question of assessment of their performance. Flood forecasting and flood warning measures are yet in the developing stage; as such, only an interim assessment could be made.

6.4.2. *Embankments*

(i) *General review*

As a measure for protection against floods, embankments have been extensively used for protection of important towns, habitations, development works and agricultural and other lands. Even in the advanced and developed countries it has been recognised as an important measure of flood protection. In the USSR there are some 200 systems of levees which provide protection to more than 8 million ha. of agricultural land and to towns, industrial complexes and other national developments. Poland, a small country compared to the size of India, had 7,731 km of embankment upto end of 1971. In India, the embankments constructed upto 1954 covered a length of about 6,000 km giving protection to about 3 million ha. During 1954—78, the length of embankments constructed was 10,821 km. The overall area protected by all types of protection measures during this period, was 9.95 million ha. the break up of the areas protected by the different types is not readily available. Details of the total area protected in

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the States with lengths of embankments exceeding 500 km. each is as under:

State	Length of embnkment km	Area protected lakh ha
Assam	4,145	13.05
Bihar	2,355	15.66
Uttar Pradesh	19174	9.16
Punjab	821	24.14
West Bengal	515	10.01
Total of 5 States . . .	9,010	72.02
Total for the country. . . .	10,821	99.85

(ii) *Performance*

On the advice of the Planning Commissions, the Union Department of Irrigation, in the Ministry of Agriculture & Irrigation, constituted a Working Group on Flood Control, Drainage and Anti-Erosions, in the context of formulation of Five Year Plan commencing from April, 1978. In the Final Report of November, 1978 the Working Group has observed that 'Embankment constructed so far have by and large given the desired protection to large areas at comparatively low costs'. Central Water Commission has given the following assessment:

> Thus by now embankments in varying lengths have been constructed on all types of rivers i.e. aggrading, degrading as well as poised rivers. If proper data of evaluation of the performance of these embankments as well as the effect on river regime as a result of construction of embankments on various types of rivers were available in a scientific form, it would have been possible to correctly assess the benefits and drawbacks of embankments rather than formulating generalised opinions on merits and demerits of embankments...As already pointed out, unless a secientific evaluation of their performance is made on the basis of a large number of case studies, it is not possible to form definite conclusion. Embankments may be considered unavoidable for protection of towns or other valuable property situated along the banks of rivers..Because of their comparatively lower initial costs and quicker benefits, embankments may remain a major component of the flood control programme even in future. Wherever feasible, they should be in conjunction with a storage reservoirs built essentially for optimum utilisation of waters including flood moderation.

The recommendations of the Ganga Floo Control Commission on the future use of embankments, by and large conform to the above view of C.W.C. The Chairman, Brahmaputra Floo Control Commission, has opined that "the embankments so far constructed have been of grea help in protecting the areas from low to mediu floods but during years of high floods, there ar large scale breaches in the embankments a could be seen during the floods of 1962, 196 1969, 1972 and 1977". He has also observed tha "drainage congestion behind embankment ha developed in a number of tributaries and on th main Brahmaputra". The overall assessments o Bihar, U.P. and Punjab about performance o embankments are not discouraging. West Benga is, however, critical about the efficacy of embankments as a flood control measures; the have stated:—

> "Although the marginal embankments ap arently shut off the floods quite effectively, yet it is at best a temporary measure, where river water carries a heav silt charge, the embankment by shutting off the spill areas on either sid hastens raising of the river bed wit consequent rise in flood levels. Thi phenomenon creates potential danger o breach of embankments. A vicious rac starts at that stage between the rise o the river bed and raising of the embankments in which the latter has not eve a remote chance to win. The real answer lies in the construction of floo detention reservoirs."

The West Bengal Government have said tha the embankments do not serve any useful purpose. In fact, however, they have constructe 175 kms of embankments during 1976-77.

(iii) *Performances of specific embankmen projects*

In our Questionnaire to the States, we wante the views of the State Government on the assessment of the benefits/drawbacks of marginal embankments on river regime, effects on downstream works/areas, protected area etc. and abou the desirability, location where suitable an other relevant matters. In addition, we had included a proforma seeking the following information with regard to each embankment schem costing more than Rs. 25 lakhs.

(a) Past breach or overtopping.

(b) Past retirement due to river attack, o protection work.

(c) Estimated assets e.g. building etc. an extent of area cultivated before and afte completion of the scheme.

(d) Post-embankment drainage congestion with average depth, duration and exten of water accumulation over the protected area.

(e) Benefits derived year by year in crop area and monetary value of the same.

(f) Quantitative evaluation of the economic condition before and after construction of embankment.

(g) Creation of additional flood problem on upstream, downstream and opposite bank, after embankment construction.

(h) River behaviours and post monsoon river survey including river cross sections.

(i) Actual performance compared to the same in the project report regarding evaluation of economic viability.

Had the State replies adequately covered all these points, with supporting data, an analysis could have been attempted by us, to arrive at quantitatively, the performance of individual embankment projects, and get a dependable picture of the overall performance. From their replies it transpired that most of the States did not have any details about item (c) to (h) above, and some not even details of (a), (b) and (i) in case of most of the projects. A summary of the State replies with regard to certain aspects of the actual performance is given in Annexure 6.8.

The position regarding non-availability of past data relating to the pre-embankment period could not be rectified. It was found that even benefits derived from the project, from year to year, in the shape of protection of crops, and other assets susceptible to flood damage, were not assessed in relation to the year's flood magnitude and duration. Any assessment of the partial negation of these benefits, due to accumulated drainage water over the protected area from year to year, were also not done. The annual benefits from embankments were, therefore, by and large, a matter of overall opinion of some individual, with no supporting data. We were, therefore, reluctant to draw any conclusion from the trend of such opinions. This general absence of data about flood control benefits, was obviously on account of no financial gain being directly related to such assessment as in the case for irrigation benefits. The other data sought by us not being of immediate applicability had not been collected by the States. Under the circumstances it has not been possible for us to make any quantitative assessment of the performance of individual projects nor conclusions based on such assessments.

(iv) *Suggestions for future evaluation of performance*

Sustained and systematic efforts are to be directed from now on for the collection of the required data for dependable evaluation of the performances of the existing and future flood control works, e.g. embankment, drainage measures, flood moderation reservoir etc. Some of the required data would be with regard to the pre-project status of (a) the proposed protected area and perhaps some neighbouring areas and (b) the river regime and its hydrology. Some of these data, if not already collected, can become available in a dependable manner only for projects to be taken up in the future. The objective of collection of data is to evaluate the performance of the project with regard to its impact on the protected area and on the river hydrology. To achieve this, the data have to be collected in an effective manner covering a fairly broad range of technical and socio-economic parameters, the eventual processing of which can be expected to yield quantitatively dependable information on the questions listed in sub-para (iii) above.

Many of the data to be collected are repetitive in nature, extending over a fairly long period of time. The evaluation of the performance will have to consider the inter-action of floods, erosive and wave action, silt, natural forces and human interferences on the control:protection work. The project authorities, successively incharge of interferences on the control|protection work thus to be entrusted with the primary responsibility of the collection of data. In the initial stages of programming the data collection and evaluation, outside help from experts in the field of evaluation of projects may, however, be necessary.

The compilation and analyses of these data have to be done at regular intervals, so as to ensure their quality and coverage as also for the appraisal whether these data are actully needed for the evaluation. In order to safeguard against probable accumulation of data without any processing, it is recommended that an annual compilation of the tentative performance reports should be published. These annual reports should contain a quantitative evaluation of the social benefit derived from the project during the year under review, apart from the details relating to finances, e.g. cost of maintenance, revenue earned and other related matters, as are usually contained in the annual reports of irrigation projects.

The specific data that have to be collected would depend upon the nature and magnitude of the project and local conditions. To ensure that the data, programmed to be collected on a long term basis, beginning from the precommencement stage through maintenance, are adequate and necessary, a thorough scrutiny of the data collection programme for the specific project should be done in the initial stages,, preferably by a team of multi-disciplinary experts. This aspect is of considerable importance as, if collection of any data is overlooked, it may not be possible to subsequently collect it in a dependable manner.

It is understandable that such comprehensive efforts to evaluate the performances of flood control projects cannot be expected to be achieved for all the projects. On the other hand, such evaluations have to be made for a reasonably large number of each type of flood protection projects, to enable a dependable assessment of the performance of each kind under varying conditions of different types of rivers and local conditions. These performance evaluations, if done for an adequate number of each type would give us an insight into the complex intractions of differing parameters which make the project a success or otherwise, thereby enabling a more objective assessment of the likely benefits from the projects to be taken up in future. In view of the large magnitude of the future programme for flood control, such objective evaluation of the likely benefits from projects, would pay rich dividends. The modest investments and efforts needed for the performance evaluation would therefore be amply rewarded. These performance evaluation should be considered to be a research programme of prototype performance study, findings of which will be of more value for the overall flood protection programme than for the particular project studied. If the financial burden of such performance evaluations are left to be States, it is apprehended that our recommendations may not be effectively implemented. We, therefore, recommend that the Centre should finance the cost of such studies on performance evaluation of selected flood control projects of various types. Apart from providing funds, the Centre should also monitor the collection of data and annual evaluations of the performance, to ensure that the quality of the study is dependable.

सत्यमेव जयते

In the absence of such evaluation it is not possible to give our opinion on the performance of the various type of flood control/protection measures.

(v) *Case studies for embankment projects.*

At our instance, the Programme Evaluation Organisation of the Planning Commission undertook evaluation studies of two embankment projects, viz. (i) Kosi embankments and (ii) Puthimari embankments. We have not yet received the final report of the case study of the Puthimari embankments, but we received the report on Kosi embankment just before the finalisation of our Report. As some of the Members raised points which go to the very root of some of the findings of the case study and as for want of time the Commission could not discuss these points with the Planning Commission and representative of the Bihar Government, it has not been possible for the Commission to adopt the report in toto. The Commission, however, agrees with the following findings of the case study:

> "The annual loss in pre-embankment period was of the order of Rs. 6 to Rs. 10 crores depending on the intensity of flooding, which on the basis of present price structure would be still higher. The same has been prevented with the construction of embankment which was completed in 1959. The total expenditure on the embankment to derive the above benefit was about Rs. 40 crores, incuding cost of special repairs and of impermeable spurs etc. constructed upto March 1978. The people the area have developed a sense of security after the flood protection and holding of the river which was of a shifting nature in its present course between the embankments.
>
> The cost of protection of the embankments against river attacks has been more than rupees one crore per year. In the absence of proper maintenance, the protected areas are likely to be exposed to serious flood hazards.
>
> On the negative side, the embankments have enhanced flood problems in the unprotected area between the two embankments. The continued rise of river bed has created problems of seepage and drainage congestion, aggravating the waterlogging problem of the protected area, particularly in a strip along the eastern flood embankment.
>
> The case study has also highlighted the interaction of irrigation introduced in the protected area and how in the absence of the whole gamut of developmental activities, tangible effect of speedy economic regeneration were not realised in most of the areas."

This single case study represents the problem of embankment along a specific aggrading river with high silt charge.

(vi) It could be summarised that despite authoritative generalised observations that embankments constructed so far had by and large served their purpose, we could not come across any statistics supporting or disproving this observation. Unless detailed data collection was commenced for evaluating the performance of embankments, it may not be possible to quantitatively assess it even in future. We are, however, inclined to conclude that embankments properly designed, constructed and maintained, afford protection to large areas; deficiencies in any of these prerequisites could lead to damage. Also that they should preferably be used in conjunction with other methods.

6.4.3. *Drainage improvement.*

In the States which had taken to drainage and channel improvements in a big way, the figures of overall area protected are available, but the break-up of area protected by each type is not readily available. The figures of area benefited for States with lengths of drainage and channel improvements exceeding 1000 km are as under:

States	Length of channel improvement drainage channel km	Total area protected lakh ha.
Andhra Pradesh	5,750	7.00
Punjab	5,493	24.14
Uttar Pradesh	2,634	9.16
Haryana	2,597	10.85
Total for four States	16,474	51.15
Total for the country	19,260	99.85

(ii) *Drainage channels.*

In response to our Questionnaire, the Central Water Commission has sent us the overall evaluation of the performance of the drainage schemes in Punjab, Haryana, Rajasthan and Gujarat, along with other measures, as extracted below:

> "The principal measures that have been taken up to keep the water table at desired limit is by construction of suitable surface drains and prevention of spills from rivers and local streams. Changes in crop pattern by cultivating crops such as paddy which can stand waterlogging and salinity and conjuctive use of ground water with flow irrigation has also been adopted. The results of these measures have been very encouraging in Punjab and Haryana, where the extent of water-logging had shown a marked reduction from 7.74 (lakh) ha. in 1970 to about 5.7 (lakh) ha. in 1976".

The GFCC have indicated that they have not conducted any post-implementation appraisal of drainage schemes. The Punjab has indicated that specific areas have come under cultivation for kharif and rabi, which were badly flood-affected before implementation of the drainage projects, and that ground water tables were lowered after implementation. The Krishna Godavari Delta Drainage Scheme in Andhra Pradesh, which was started in 1970 to eventually benefit 5.36 lakh hectares by providing relief in drainage congestion was reported to be still in execution stage. The State reply has indicated that benefits actually derived during execution have not been evaluated by them as the scheme is still in progress. Haryana has given only a general observation that the benefits actually derived are much more than those stipulated in the projects. Uttar Pradesh has indicated that no studies have been carried out to evaluate in quantitative terms the area benefited before and after the completion of the schemes. It has, however, been indicated that ground water table had gone down from 1.83 metres to 2.44 metres after implementation of a specific project. West Bengal has reported that it has not evaluated the benefited areas.

The above review would indicate that the performance of individual drainage projects could not be quantitatively evaluated from the data made available to us. The overall performance is reported to be satisfactory with which we agree.

(iii) *Channel improvements.*

According to the Report of the Central Water Commission, the scheme on the Jhelum in Kashmir commenced in 1961-62 for increasing the capacity to 1132 cumecs in the reach downstream of Wullar Lake is still in progress. The estimated cost of Rs. 8 crores has been revised to Rs. 22 crores, and so far the capacity could be increased to above 8495 cumecs which is claimed to have lowered the HFL. The project, even at the construction stage, is facing problem of silting for which ameliorative measures are being considered.

Some of the States also have furnished lists of some of the channel improvement projects but sufficient details on the performance have not been supplied. Central Water Commission has opined that this type of works were costly and could be taken up only in limited specified reaches each case of channel improvement needing study on its merit and no generalised statement, either recommending channel improvement or otherwise could be made.

We are not in a position to make any quantitative evaluation of the performance of this type of measures based on the performance of the individual projects. While discussing the methods of channel improvement, we have summarised in chapter V. that though well recognized, this method should be tried with caution, after due examination of its technical and economic viability and ensuring that the improvement to be brought about are of a sustained nature. We could not find from the performance reports any reason to review this observation. In case of channel improvement and drainage channels, we would like to reiterate the recommendations made by us in the case of embankments *viz.* the need of collection of dependable data on the performance of a reasonably large number of projects for arriving at a proper evaluation.

6.4.4. *Flood moderation reservoir.*

(i) The Central Water Commission has furnished us with the brief details of some of the completed reservoirs which have some flood control aspects. This list includes the Hirakud Project in Orissa, the Damodar Valley Project for the benefit of Bihar and West Bengal and the Baigul Reservoir in U.P. Brief details have also been given for proposed/under progress, projects of Rengali Dam on the Brahmani river, Bhimkund Project on the Baitarni river both in Orissa. Multi-purpose Reservoirs on the Subarnarekha for the benefit of Orissa, Bihar and West Bengal, Halali Dam in Madhya Pradesh and Macharbali Dam in Karnataka. West Bengal has indicated that the completed Kangsabati reservoir has an earmarked flood storage of about 28 per cent of the live storage.

The Baigul Reservoir has a small storage of only 94 million cu.m. and adequate details are not available. As seen from West Bengal's reply the Kangsabati reservoir has no operation rules drawn up so far, nor have the moderation benefits been evaluated. Thus, as far as fairsized reservoirs are concerned, details of performance are available only with regard to the Hirakud and DVC reservoirs.

(ii) *Hirakud Reservoir.*

As per the CWC, the reservoir has no earmark-flood storage as such. The entire storage during the monsoon season is utilised for flood moderation and subsequently filled up for irrigation and power generation. The initial operation procedure resulted in difficulties twice during the first twenty years of its introduction. Once, the reservoir could not adequately moderate the flood due to the inadequacy of the capacity available at the time of the flood. Second time, the reservoir could not be filled up to the storage level needed for irrigation and hydel requirements due to withdrawal of the monsoon earlier than envisaged in the operation schedule. Consequently, the initial operation procedure was modified.

Flood protection is achieved in the lower valley of the Mahanadi by the conjunctive method of flood moderation at Hirakud and embankments in the dower valley. Orissa has reported that consequent to the flood moderation by the Hirakud reservoir, the peak flood in the downstream reach has been reduced to a great extent, though the durations of low and medium floods have been prolonged. The area benefited and its monetary value due to flood moderation have not been evaluated so far. The report of Orissa indicates that no appreciable encroachment has been observed in the downstream reach of the river after completion of the Hirakud Project. There is a plan to strengthen the embankments in the lower valley to withstand a peak discharge of 31,140 cumees against the present discharge of 24,060 cumecs.

(iii) *Damodar valley reservoirs.*

The replies of both the CWC and West Bengal indicate that the flood moderation affected through specifically earmarked flood storage in these reservoirs were tangible, though not upto the maximum possible extent as per the project, due to non-acquisition of land in the reservoir areas upto the maximum water levels envisaged. The process of acquiring these lands is now in hand. The drainage capacity of the lower Damodar basin has considerably deteriorated since the inception of the project. The ameliorative measures for relieving the surface drainage congestion in the lower basin could not be taken up simultaneously with the upland storages. The moderation of the flood peak probably encouraged further encroachment into the channel water-way lower down; this tendency could not be controlled. The cumulative result of all these factors has been that despite the outflow, after the flood moderation having been reduced to 25 per cent or even less than the inflow, even this causes flood in the lower basin. The problem becomes more acute, when the release from the reservoirs synchronise with the runoff from the uncontrolled catchment. The feasibility of ameliorating the residual flood problem is under study. The Report of the DVC case study conducted by the Commission is enclosed as Appendix VII.

(iv) Most of the reservoirs completed in the country do not have any specific operation schedules for moderation of floods. Of the few that have any recognised function of flood moderation, only the Hirakud reservoir and the DVC reservoirs have tangible moderation effects. In the case of the Bhakra Reservoir, advance information from meteorological stations in the catchment enable timely depletion of the reservoir to moderate incoming floods. In case of Ukai Reservoir, the observed maximum flood at dam site was 42,470 cumecs. After completion of the reservoir the outflow could be regulated to only 22,650 cumecs. Thus, there will be positive benefit towards flood moderation from these two reservoirs. Similar moderation is achieved incidently in many of the multi-purpose reservoirs, though not specifically intended for the purpose of flood moderation. Some more multipurpose reservoirs, with flood moderation, as one of their important functions are under project preparation stage, and one such reservoir namely the Rengali Reservoir in Orissa is under construction. The reservoirs so far operated have indicated the efficacy of this type of measures. The experience of the performance has, however, highlighted the need of a comprehensive operation schedule for the reservoir and the need for simultaneous ameliorative measures in the lower valley so as to safeguard against deterioration of the drainage capacity of the lower valley.

6.4.5. *Raising of villages.*

The report from U.P. in this context is particularly significant, because, 96 per cent of the villages raised in the country are in this State. They have reported that "the general performance of this work suffers from the limitation that it does not provide protection to the agricultural land and the communication during floods is also interrupted. With the increase of the pressure on the land and improved varieties of crops, the protection to agricultural area becomes equally important.......The raising of village has not been considered very useful." We, however, feel that as mentioned in chapter XIV, despite these drawbacks, there is considerable scope for adoption of this method.

6.4.6. *Anti-erosion and Town Protection works*

The CWC has stated that the assessment of anti-erosion work so far carried out indicates that they are extremely costly both in capital outlay as well as in maintenance. The CWC also opines that traditional works like spurs do cause adverse effects in the vicinity. They have also informed us that there was reluctance on the part of the States to undertake any scientific analysis of the behaviour and performance of this type of measures.

The GFCC has indicated that for protection of towns and important communications, anti-erosion works were suitable, but for the protection of agricultural land they would not be economically viable. The GMCC has opined that anti-erosion works should be taken up only after careful technical planning.

The performance of anti-erosion and town protection projects would be different in each individual case, depending on several parameters which would not necessarily be applicable elsewhere. We have come across instances of good performance of these measures, and feel that these measures may be tried after examination of the technical and economical viability and other possible alternatives.

The Central Water Commission has recommended sanction of grants to the States Governments for doing applied research on prototype studies of river training works and their performance, and a long term programme of data collection on river behaviour. We endorse these views and feel that properly designed anti-erosion works have withstood and given the desired protection although they are costly in capital as well as maintenance and repairs.

6.4.7. *Watershed management*

Watershed management in the catchments of selected reservoirs have been taken up under the centrally sponsored projects in 13 Nos. of selected River valley projects during the Third Plan, which was extended to 30 River Valley Projects during the Fifth Plan. Programme were taken up, even before that, in the DVC and Bhakra reservoir catchments. All these programmes, except a few like those in the Damodar Valley Catchment, were not for providing flood control benefits. Some of them, however, help in prolonging the life of reservoirs by reducing the silt load of the runoff and thus contributing towards flood protection benefits, if any, from these reservoirs. In case of the Damodar Valley the evaluation of benefits from watershed management of small catchments of a few square km each are available, but so far, performance of these methods have not been assessed in a quantitative manner on a long term basis from the angle of flood control.

6.4.8. *Flood forecasting and flood warning*

(i) The flood forecasting services assume considerable significance not only in the unprotected flood prone areas for organising rescue and relief operations and thus provide scope of reducing flood damages, but also in the areas already protected by giving advance intimation of related data to engineering authorities for keeping the required vigil for safeguarding the engineering structures and for more efficient operation of reservoirs and floodways. The flood forecasting programme initiated in 1959, in a modest manner on the Yamuna river, has now covered almost all the inter State river basins prone to heavy damages. The Central Flood Forecasting Organisation of the Central Water Commission is discharging the function of flood forecasting in major flood prone basins; in some States there are State Flood Forecasting Cells which function in close co-ordination with the Central Organisation.

Flood warning essentially consists of communicating and disseminating in time the information about incoming floods its magnitude and the consequent damage that is likely to result, so that the civil authorities and the people likely to be affected can take necessary measures to reduce damages to life and property.

(ii) *Technique and methodology so far applied*

Initially forecasts were formulated on the basis of stages of main rivers. This was subsequently supplemented by incorporating data of rainfall in the intervening catchment with appropriate antecedent precipitation index utilised as a parameter. The process was further improved by incorporating the stages of tributaries joining the river. All these led to formulation of forecasts with the help of Multiple Corelation Diagrams, mathematical equations for corelating the stages and other parameters.

Discharge corelation and sttream-flow routing method are also applied now. Conceptual models consisting of a linear reservoir and linear channel in series have been attempted for some reaches of the river Yamuna. A similar multi-tributary model is now being developed for the river Brahmaputra. It is proposed to formulate forecasts on the basis of hydrometeorological data on the basis of unit hydrograph developed at forecast sites of smaller rivers. With progress in the technique of quantitative forecast of precipitation and installation of more self recording rain-gauges in the catchments of smaller rivers, this technology is expected to bring improvements.

(iii) *Present Organisation.*

The Central Flood Forecasting Organisaticn under Member Floods CWC has two Chief Engineers one each at Patna and Hyderabad and a contingent of Superintending Engineers, Executive Engineers and other officers and staff in various parts of the country. The India Meteorological Department have flood Meteorological offices at Patna, Bhubaneswar, Gauhati, Jalpaiguri, Lucknow, Delhi and Surat. The salient features of the overall flood-forecasting activities are as under:

(i)	Number of forecasting centres	12
(ii)	No. of control rooms	50
(iii)	No. of forecast sites	120
(iv)	No. of gauge/discharge sites	320
(v)	No. of rain gauge/self recording rain gauge stations.	500
(vi)	No. of wireless sets.	428
(vii)	Maximum No. of forecasts in one year	7,385
(viii)	Apprdiximate annual expenditure.	Rs. 1.5 crores

(iv) *Some notable achievements.*

(a) In 1970, the peak flood of the Narmada in Gujarat was forecast 24 hours in advance.

(b) In 1971, the flood stage of the Ganga in Bihar with an accuracy of 2 cm of the actual was given 24 to 30 hours in advance. During 1975 the flood forecast was given 24 hours in advance in Bihar.

(c) In the 1977, a flood warning for Sahibi River near Delhi could be given 5 days in advance.

(d) During the 1978 flood, forecast could be given 24 to 72 hours in advance of the incoming peaks at different locations in the basins of the rivers Ganga, Yamuna, Brahmaputra, Brahmani, Subarnarekha, Baitarani, Tapi etc.

All these forecasts gave margin of time for intensifying surveillance of engineering works and timely rescue and relief operations, thus providing considerable help in mitigation of flood damages.

(v) The performance of flood forecasting has been impressive during the past years. Its activities have now been extended to almost all important flood prone rivers. With progressive availability of more advanced techniques, there is need for further modernisation of the forecasting system.

सत्यमेव जयते

ANNEXURE 6.1

Floods of India—problem and remedies

Statement by Shri Gulzarilal Nanda, Minister for Planning and Irrigation and Power, in the Lok Sabha on September 3, 1954.

I shall give a brief assessment of the problem of floods in the country and the existing situation on the basis of discussions with technical experts and representatives of the various States concerned, the available material on the subject and a personal survey of the conditions in the affected areas. I shall also indicate the nature of remedial action that is feasible in the circumstances and outline the programme which is being considered with a view to securing a very large measure of protection from flood hazards in the vulnerable areas. The situation created by the floods this year in north-eastern region of India may be summed up in a few words and figures. A total area of 25,650 square miles and nearly 95 lakh of people have been affected. The floods have taken a toll of 247 lives. Over 7,700 cattle have perished. Crops have suffered damage over an area of about 137 lakh acres valued approximately at Rs. 40 crores. There has been large scale destruction of houses. Considerable areas of valuable land have been lost on account of erosion and deposit of sand. Damage to roads, railways and bridges has been enormous and the consequent disruption of communications has been on a scale never experienced hitherto.

Elaborate arrangements have been made everywhere for rendering immediate assistance and relief. Nearly Rs. 5 crores, 75 lakhs have already been made available of which gratuitous relief and agricultural loans amount to Rs. 196 lakhs and Rs. 329 lakhs respectively. The Central Government has offered to share the burden which the States have to carry on this account.

Floods have been recurring in various parts of the country at intervals in the past. But in point of extent and intensity, the floods of this year have been the worst over a long period.

I asked the States of Assam, Bihar, West Bengal and U.P. to report the figures of the area affected as also the extent of damage to life and property during the last five years. It emerges from the information that has been furnished that in Assam during the last five years there have been four heavy floods—two covering extensive areas and the other two somewhat restricted in extent—while in 1953 the floods were of a mild nature. In Bihar during the last five years, there have been two severe floods and two mild ones, while 1951 was a normal year. In U.P., there have been three heavy floods and one mild during the last five years. 1951 was a normal year when there were no floods in U.P. In West Bengal there were three heavy floods out of which two were restricted in extent and one, i.e., of the current year was exceptional both in the severity and extent of flooding. In addition there were mild floods in 1953 and 1951. Last year there were heavy floods in the Godavari in the South, when a discharge of 2.8 million cusecs was recorded over Dhowlaiswaram weir. Floods were experienced in July 1948 and September 1950 in the Kashmir Valley also. It is evident that we are facing here a tremendous problem, the solution of which cannot brook any delay.

It must be acknowledged, on the other hand, that in the past years, there was lack of sustained and systematic effort to deal with the problem on a comprehensive basis. The neglect is particularly unfortunate in respect of the collection of hydrological and other data without which no remedial measures of a reliable character can be devised. Some steps have recently been taken to make up this deficiency. Very much more remains to be done. It has been decided that the highest priority should be accorded to the work of getting together the basic data. It will be our earnest effort to carry through the necessary surveys and investigations without the least delay. This will require close collaboration among the various departments and agencies of the Central and the State Governments.

The nature of the problem of floods in this country determines our approach in dealing with it. So far as the Himalayan rivers are concerned, heavy rainfall occurring in a short space of time simultaneously over a very extensive catchment area is the principal factor in the situation. The steep slopes of the rivers as they enter the plains and the absence of any easy outfall facilities greatly increase the intensity of floods. This has been further aggravated by the deforestation in the upper catchment areas and the consequent soil erosion and silting of beds of the rivers which results in shifting of their courses. This particular aspect must receive much more attention than has been the case hitherto.

Construction of storage reservoirs and diversion channels, wherever feasible, is obviously amongst the most effective measures for the control of floods. The multipurpose development of the Damodar, the Mahanadi and the Kosi, three of the most destructive rivers in the country, will, after the completion of the projects now under way, provide substantial protection from floods in the areas they have been devastating hitherto. The Bhakra Dam on the Satluj, the Matatila Dam on the Betwa, a Dam on Rihand, a tributary of the river Sone, the Gandhi Sagar Dam on the Chambal, are multi-purpose in conception and, although flood control was not the dominant consideration, the areas through which they flow will be protected to a large extent from floods. The question of constructing dams across the Krishna, the Narbada and the Tapi is also under examination. A scheme for the control of floods in the Kashmir Valley has recently been worked out with the assistance of the Central Water and Power Commission.

An adequate programme of storage works in relation to all the areas which are liable to floods has to be thought of mostly as a part of the long-term development of the country.

Such, however, is the urgency of the need for protection to the people in the flood-affected areas that we have to choose the methods which, while achieving the object, can be carried out expeditiously. A programme in these terms is being considered for adoption. It is divided into three phases:

Immediate.—The first phase will extend over a period of two years. This period will be devoted to intensive investigation and collection of data. Comprehensive plans will also be drawn up and designs and estimates prepared for short-term measures of flood protection. Some measures such as revetments, construction of spurs and even embankments may be applied immediately in selected sites.

Short-term.—During the second phase, which may be taken to start with the second year and would extend to the sixth or the seventh year, flood protection measures, such as embankments and channel improvements, will be undertaken. This type of protection will be applicable to a major portion of the areas now subject to floods.

Long-term.—The third phase will relate to selected long-term measures such as the construction of storage reservoirs on tributaries of certain rivers and additional embankments, wherever necessary. This may take three or five years more.

A complete answer to the problem of floods may not be found in any single measure. Each case will have to be considered on its merits and a measure or a combination of measures adopted if a proper solution is to be found.

To ensure that the measures outlined above are carried out, it is proposed to create, with the consent of the States concerned, Flood Control Boards in the States which are liable to frequent floods. The Boards will be constituted in U.P., Bihar, West Bengal and Assam in the first instance. Andhra and other States which are liable to floods will also be requested to adopt the same course. It will be the duty of these Boards to assess the flood problem in their areas and to (a) collect data, (b) prepare a comprehensive flood control scheme for the State, (c) indicate priorities, and (d) ensure the implementation of approved schemes. These Boards will be assisted, wherever necessary, by technical committees for the collection of data and the preparation of schemes.

A Central Flood Control Board will also be constituted on which the Union Ministry of Irrigation and Power and the State Boards will be represented. The Central Board will consider the schemes submitted by State Boards and draw up a national flood control programme, having regard to the availability of finance and technical personnel. The Central Board will also be assisted by a strong technical committee consisting of experts in flood engineering, soil conservation and agriculture. Experts from other countries and ECAFE will also be invited to assist this committee, wherever necessary. The Central Technical Committee will be assisted by the Central Water and Power Commission.

It is difficult to estimate with any degree of accuracy the cost of the measures that are being envisaged to ensure flood protection in all States in India. Only a very rough estimate is possible at this stage. For U.P., North Bihar, West Bengal and Assam, an approximate estimate based on incomplete data comes to about Rs. 175 crores—Rs. 100 crores for 'Immediate' and 'short-term' measures and Rs. 75 crores for 'long-term' measures involving storages on the tributaries of rivers in North Bihar and Assam. The short-term programme in these States can be completed over a period of about six to seven years. The picture will become clearer and the estimates more firm as investigations progress and designs are drawn up. Similar measures required in relation to the problem of floods in other States will need a relatively small amount. The cost of the works can be reduced to a substantial extent by enlisting the co-operation of the people in various ways. Contribution in the shape of voluntary labour is an important form in which people can help, while graded protection levies would be perfectly legitimate where protection works are undertaken at the cost of the State.

I may in conclusion express the conviction that the floods in the country can be contained and managed, and that the problem is capable of solution. It is obvious, however, that a programme of flood control on the scale visualised cannot be completed in a short time unless the energy of the people and the resources of the Nation are mobilised effectively on a large scale. The administration and the people have both to share the responsibility and to undertake tasks of a huge magnitude in order that the country may be rid of the menace of floods.

ANNEXURE 6·2

Statement showing state wise actual expenditure on flood control, drainage, anti sea-erosion and anti water logging schemes during 1st, 2nd, 3rd, 1966—69, 4th and 5th plan supplied by Planning Commission

(In Rs. crores)

Sl. No.	Name of State/ Union Territories	1st Plan	2nd Plan	3rd Plan	1966-69	4th Plan	5th Plan	(1st 4 years of the 5th Plan)			Total upto 1977-78
		Actual Expenditure	Actual Expenditure	Actual Expenditure	Actual Expenditure	Actual Expenditure	1974-75 Actual Expenditure	1975-76 Actual Expenditure	1976-77 Revised approved	1977-78 approved	
1	Andhra Pradesh	..	2·62	1·49	0·26	0·70	4·30	3·46	4·60	3·85	21·28
2	Assam	2·88	4·22	11·40	9·00	31·88	1·04	1·76	1·96	3·75	67·89
3	Bihar	5·15	19·88	13·65	4·75	25·15	8·00	13·80	20·00	13·50	123·88
4	Gujarat	..	0·30	0·39	0·43	5·32	1·55	0·94	1·50	2·90	13·33
5	Haryana	——Shown under Punjab——			3·15	8·47	1·36	1·33	3·60	1·95	19·86
6	Himachal Pradesh	..	..	..	0·05	0·08	0·22	0·09	0·09	0·10	0·63
7	Jammu & Kashmir	0·45	1·99	5·46	3·63	6·01	1·31	1·53	4·12	3·00	27·50
8	Karnataka	..	..	..	0·03	..	0·08	0·11	0·50	0·50	1·22
9	Kerala	..	0·50	5·16	2·10	11·37	1·57	1·57	1·53	1·50	25·30
10	Madhya Pradesh	0·01	0·03	0·08	0·02	0·52	0·14	0·18	0·40	0·46	1·90
11	Maharashtra	..	..	0·09	0·06	0·29	0·05	0·05	shown under irrigation	0·40	0·94
12	Manipur	..	..	..	0·22	1·03	0·33	0·27	0·75	0·40	3·00
13	Meghalaya	..	..	..	..	0·05	0·14	0·14	0·16	0·14	0·63
14	Nagaland	..	..	..	..	..	..	..	..	..	0·00
15	Orissa	0·16	1·97	0·98	1·01	5·00	0·69	2·75	1·00	1·66	17·47
16	Punjab	0·11	5·23	27·31	5·97	12·01	3·30	4·00	5·00	5·46	69·69
17	Rajasthan	..	9·08	3·52	3·13	2·32	0·41	0·30	2·40	1·00	13·16
18	Sikkim	..	..	..	..	..	..	..	..	..	..
19	Tamilnadu	..	..	..	..	0·29	0·21	1·05	0·27	0·64	2·46
20	Tripura	..	..	..	0·32	0·56	0·14	0·15	0·43	0·30	1·90
21	Uttar Pradesh	2·76	7·99	6·96	3·07	22·06	4·41	6·50	15·02	12·00	80·77
22	West Bengal	3·64	2·31	4·13	3·02	26·63	6·11	8·05	11·84	12·92	76·65
	TOTAL STATES	1·16	47·12	83·07	40·28	160·84	35·36	48·03	75·17	66·43	569·46
1	Andaman & Nicobar Islands			..	..	..	..	..	..	..	..
2	Arunachal Pradesh			..	..	..	0·0033	0·0196	0·01	0·05	..
3	Chandigarh			..	..	..	..	..	..	..	
4	Dadra & Nagar Haveli			..	..	..	..	0·0004	0·0005	0·0005	
5	Delhi			2·70	3·25	6·26	1·69	1·83	2·20	3·56	24·61
6	Goa, Daman & Diu	0·05	0·94	..	..	0·23	0·0643	0·0517	0·01	0·20	..
7	Lakshwadeep			..	..	..	0·0128	0·01	0·01	..	..
8	Mizoram			..	..	..	..	..	..	..	..
9	Pondicherry			0·02	0·09	0·52	0·1124	0·1111	0·17	0·2270	
10	Laccadive Islands			..	..	..	..	..	..	..	..
11	Manipur			0·11	..	..	..	..	..	..	..
12	Himachal Pradesh			..	..	..	..	..	..	..	
13	Tripura			0·10	..	..	..	..	..	..	
	TOTAL UNION TERRITORIES	0·05	0·94	2·93	3·34	7·01	1·8828	2·0228	2·4005	4·0375	24·61
	Central Sector	..	..	..	..	3·93	7·51	8·26	11·05	12·71	45·11
	Other Scheme	0·56	1·09	..	..	..	..	..	..	..	..
	GRAND TOTAL	13·77	49·15	86·00	43·61	171·78	44·75	58·31	88·62	83·18	639·18

ANNEXURE 6.3

Physical Achieoement of Flood Control Works Since 1954

(Area benefited in lakh hectare)

Name of State	Area benefited since 1954							
	Upto 1964	Upto 1969	Upto 1972	Upto 1974	Upto 1975	Upto 1976	Upto 1977	Upto 1978
Andhra Pradesh	0·28	0·28	0·28	0·28	5·68	6·18	6·59	7·00
Assam	3·24	7·16	7·28	7·50	8·72	8·75	13·05	13·05
Bihar	12·40	12·40	18·40	15·00	15·00	15·00	15·26	15·66
Gujarat		0·47	0·50	0·50	N.A.	2·12	3·62	3·62
Haryana		3·64	3·64	9 50	10·38	10·50	10·70	10·85
Himachal Pradesh								0·05
Jammu & Kashmir	0·12	0·12	0·12	0·12	0·12	0·12	0·12	0·38
Kerala	0·04	0·08	0.08	0·08	0·09	0·10	0·11	0·11
Karnataka				0·01	0·01	0·01	0·01	0·01
Madhya Pradesh								
Maharashtra		0·01	0·01	0·01	0·01	0·01	0·11	0·01
Manipur		0·66	0·66	0·66	0·66	0·66	0·68	0·70
Meghalaya						0·50	0·65	0·65
Orissa	3·06	3·06	3·06	3·06	3·06	3·06	3·16	3·65
Punjab	12·24	16·52	19·40	21·00	22·60	23·07	23·57	24·14
Rajasthan	0·16*	0·16	0·16	0·16	0·16	0·16	0·16	0·16
Tamilnadu					0·22	0 23	0·30	0·30
Tripura		0·04	0·04	0·04	0·04	0·07	0·08	0·11
Uttar Pradesh	4·29	5·18	5·47	6·16	6·41	6·61	6·83	9·16
West Bengal	1·54	5·31	5·31	5·31	6·76	7·71	8·81	10·01
Delhi		0·01	0·01	0·20	0·20	0·21	0·23	0·23
Goa, Daman & Diu								
TOTAL	37·37	55·04	58·42	69·59	80·12	85·07	94·04	99·85

NOTE: —All figures of physical achievements are based upon C.W.C. record, except those indicated below for which available state figures have been taken.

Uttar Pradesh C.W.C. figures for 1969 is 6·64 lakh hectare
„ „ 1972 is 6·79 „ „
„ „ 1974 is 6·66 „ „
„ „ 1975 is 6·35 „ „
„ „ 1976 is 6·57 „ „
„ „ 1977 is 6·79 „ „

*Needs reconciliation.

ANNEXURE 6.4

Physical achievements of Flood Central Works since **1954**

Length of embankments

Name of State	Length of embankments constructed (in km) since 1954							
	upto 1964	upto 1969	upto 1972	upto 1974	upto 1975	upto 1976	upto 1977	upto 1978
Andhra Pradesh	150	240	240	405	405	405	405	405
Assam	2,079	3,161	3,300	3,373	3,408	3,488	4,145	4,145
Bihar	1,108	1,772	1,772	2,192	2,238	2,265	2,325	2,355
Gujarat		24	24	24	68	158	208	208
Haryana		105	105	352	362	379	381	396
Himachal Pradesh				2	2	2	2	2
Jammu & Kashmir								
Kerala			11	23	27	34	44	44
Karnataka								
Madhya Pradesh								
Maharashtra					26	26	26	26
Manipur							45	127
Meghalaya						20	35	45
Orissa	61	93	143	155	185	245	270	370
Punjab	320	432	435	435	730	770	790	821
Rajasthan		82	82	82	82	82	82	82
Tamilnadu								
Tripura					24	24	28	39
Uttar Pradesh	446	862	921	989	1,020	1,060	1,092	1,174
West Bengal	175	280	280	280	280	340	425	515
Delhi					60	60	60	60
Goa, Daman & Diu						2	7	7
TOTAL	4,339	7,056	7,318	8,312	8,917	9,360	10,370	10,821

सत्यमेव जयते

NOTES—All figures of physical achievements are taken from CWC record where available except those indicated below for which available State's figures have been taken.

1. Bihar : CWC figure for 1974, 1975 is 1772 Km.
2. Haryana : CWC figure for 1974, 1975 is 155 and 331 km. respectively.
3. Kerala : CWC figures for 1969, 1974, 1977 are 43, 60 and 46 Km. respectively.
4. Orissa : CWC figure or 1972 is 183 Km.
5. Punjab : CWC figure for 1975 is 750 Km.
6. U.P. : CWC figures for 1969, 1972, 1974, 1975 are 14,722, 894 and 924 Km. respectively.

ANNEXURE 6.5

Physical Achienement of Flood Control Works Since 1954

Length of Drainage Channels (in km.)

Name of State	Length of drainage channels since 1954							
	upto 1964	upto 1969	upto 1972	upto 1974	upto 1975	upto 1976	upto 1977	upto 1978
Andhra Pradesh		48	48	48	4,200	4,500	5,000	5,750
Assam	385	770	770	770	770	772	772	772
Bihar	222	335	355	355	365	365	365	365
Gujarat		117	225	225	239	271	319	319
Haryana		1,520	1,520	2,228	2,257	2,493	2,513	2.597
Himachal Pradesh								11
Jammu & Kashmir								
Kerala					3	4	6	6
Karnataka								
Madhya Pradesh								
Maharashtra								
Manipur					11	16	16	31
Meghalaya								
Orissa	4	6	6	6	16	17	19	22
Punjab	3,500	4,500	5,026	5,087	5,200	5,267	5,392	5,493
Rajasthan		134	134	134	134	134	134	134
Tamilnadu					19	19	19	19
Tripura					94	94	94	94
Uttar Pradesh	718	1,523	1,700	1,968	2,060	2,134	2,334	2,634
West Bengal	108	163	278	278	449	529	564	689
Delhi				221	311	315	315	315
Goa, Daman & Diu						7	9	9
TOTAL	4,937	9,116	10,062	11,320	16,128	16,937	17,871	19,260

NOTES—All figures of physical achievements are taken from CWC record where available except those indicated below for which available State's figures have been taken.

Gujarat : C.W.C. figure for 1977 and 1978 is 271 km.

Haryana : C.W.C. figure for 1977 is 2507 km.

Punjab : C.W.C. figures for 1969, 1974 are 4480 and 5026 respectively.

ANNEXURE 6.6

Physical achievements of Flood Control Works since 1954

No. of tonns protected

Name of State	Number of towns protected since 1954							
	upto 1964	upto 1969	upto 1972	upto 1974	upto 1975	upto 1976	upto 1977	upto 1978
Andhra Pradesh					8	8	8	8
Assam	29	29	42	49	49	50	50	50
Bihar	6	6	6	16	16	18	20	22
Gujarat		27	27	27	27	27	27	27
Haryana							3	3
Himachal Pradesh								
Jammu & Kashmir		2	2	2	2	2	2	2
Kerala		1	1	1	1	1	2	2
Karnataka								
Madhya Pradesh		5	5	5	9	9	9	11
Maharashtra		2	6	6	13	15	15	15
Manipur			1	1	1	1	1	1
Meghalaya						1	2	2
Orissa	5	5	5	5	9	10	10	10
Punjab							3	3
Rajasthan		13	13	13	13	13	13	13
Tamilnadu								
Tripura						5	6	6
Uttar Pradesh	17	38	38	41	41	44	53	53
West Bengal	21	21	21	21	27	29	30	34
Delhi								
Goa, Daman & Diu			1	1	1	2	2	2
TOTAL	78	149	168	188	217	235	256	264

ANNEXURE 6.7

Physical achievements of Flood Control Works since 1954

Number of Villages raised

Name of State	Number of villages raised since 1954							
	upto 1964	upto 1969	upto 1972	upto 1974	upto 1975	upto 1976	upto 1977	upto 1978
Andhra Pradesh		21	21	21	21	21	21	21
Assam								
Bihar								
Gujarat			3	3	30	30	30	30
Haryana				90	90	90	90	90
Himachal Pradesh								
Jammu & Kashmir		5	5	5	5	5	5	5
Kerala			4	4	4	4	6	6
Karnataka								
Madhya Pradesh								
Maharashtra								
Manipur							1	1
Meghalaya						4	6	6
Orissa	7	7	7	16	29	29	29	29
Punjab		7	7	7	7	7	7	7
Rajasthan								
Tamilnadu							2	2
Uttar Pradesh	4,329	4,500	4,500	4,500	4,500	4,500	4,500	4,500
West Bengal								
Delhi								
Goa, Daman & Diu								
TOTAL	4,336	4,540	4,547	4,646	4,686	4,690	4,697	4,697

NOTE :—All figures of physical achievements are taken from CWC record, where available except those indicated below for which available State's figures have been taken.

Orissa : CWC figure for 1974 is 16 and for 1975, 1976 it is 34 villages.

U.P. : CWC figure for 1969, 1972, 1974, 1976, 1978 is 4511 villages.

ANNEXURE 6.8

Performance of embankments in a few flood-prone States as per data available in State Replies

	Assam		Bihar		U.P.		Total of Percentage 3 States	
	No.	%	No.	%	No.	%	No.	%
1. No. of case reported for the State .	90	88·2	8	7·8	4	3·9	102	
2. Drainage Congestion								
(a) No problem	49	54·4	7	87·5	4	100·0	60	58·8
(b) With problem	18	20·0	..	..	..	..	18	17·6
(c) Not reported	23	25·6	1	12·5	..	..	24	23·5
3. Breaches								
(a) No breach	26	28·9	2	25·0	1	25·0	29	28·4
(b) Frequency less than 1 in 4 years .	26	38·9	3	37·5	3	75·0	32	31·4
(c) Frequency upto 1 in 4 years .	15	16·7	..	..	..	..	15	14·7
(d) Not reported	19 +4	25·6	3	37·5	..	..	26	25·5
4. Retirements								
(a) No retirement	28	31·1	1	12·5	2	50·0	31	30·4
(b) Only one retirement . . .	15	16·7	2	25·0	2	50·0	19	18·6
(c) More than one retirement . .	17	18·9	2	25·0	..	..	19	18·6
(d) No information . . .	30	33·3	3	32·5	..	..	33	32·4
5. Overall performance								
(a) Satisfactory	25	27·8	..	..	2	50·0	27	26·5
(b) Unsatisfactory	6	6·7	..	..	..	..	6	5·9
(c) Not reported	50	65·6	8	100·0	2	50·0	69	67·6

सत्यमेव जयते

VII. ZAMINDARI EMBANKMENTS

7.1. Introduction

7.1.1 The term 'Zamindari' embankments connotes small bunds, dykes and levees put up by 'Zamindars', literally meaning landlords or owners of lands as localised individual efforts primarily to protect their lands and properties against floods in specific areas. Such embankments are the earliest efforts of protection against floods in this country. These were usually constructed in isolated places and without much technical know-how. The result was a haphazard growth of local bunds built over the centuries concentrated mainly in the four States of West Bengal, Orissa, Bihar and Uttar Pradesh. Construction of zamindari embankments may also have been due to "permanent settlement" introduced in the country by Lord Cornwallis towards the latter part of 18th Century in the erstwhile province of Bengal (later divided into the provinces of Bengal, Bihar & Orissa) and eastern Uttar Pradesh conferring titles on the zamindars. Due to lack of resources and planning, these stray works were generally sub-standard and not capable of withstanding the pressure of recurring floods. Not being systematically or scientifically planned, for want of adequate records of flood heights, the embankments suffered several breaches. The standard of their maintenance which was the responsibility of the zamindars was very often poor.

7.1.2 Such lack of planning, by and large, equally applies to some embankments constructed under some relief programmes of the Government like test relief embankments, etc. In order to provide immediate employment opportunities to people affected by natural calamities like flood, drought, etc., these works are usually constructed at short notice.

7.2. Statewise details

7.2.1 As already stated, zamindari embankments exist mainly in the States of West Bengal, Orissa, Bihar and Uttar Pradesh. A number of test relief embankments also have been constructed in these States. Similar embankments also exist in Manipur. In Jammu & Kashmir, zamindari embankments were in existence in the form of dowel bunds of discontinuous lengths with gaps at drainage crossings. Their length varies from a fraction of a kilometre to several kilometres.

7.2.2 By and large, no State has complete details of zamindari/test relief embankments, etc. However, with the abolition of zamindari system, the maintenance of these embankments was taken over by the Revenue Departments of the States. In some States, some of the important zamindari embankments were later transferred by the Revenue Department to the Irrigation/Flood Control Department. As per statistics (which are only partial) furnished by the States, total length of these embankments is about 7,546 km. protecting an area of 4.43 lakh hectares and a population of 10.52 lakhs. The position in the various States is as under.

7.2.3 *West Bengal*

In West Bengal, the largest network of zamindari embankments exist in the Sunderbans area where a total length of about 3520 km were constructed by zamindars and private individuals in order to reclaim 2.59 lakh ha from tidal inundation. These embankments were constructed along the numerous tidal creeks and in many cases are in the form of circuit embankments. This practice of premature reclamation of areas by putting marginal embankments along the innumerable tidal rivers and creeks for protecting low lying areas against tidal inundation was started as early as in the year 1770 during the days of the East India Company. This activity continued in an unplanned and uncoordinated manner without considering the overall requirement of the entire area for a period of 139 years. It was only in the year 1909 that further reclamation was stopped in order to avoid increasing drainage obstructions in the basins south of Calcutta.

Zamindari embankments were also constructed along the rivers Damodar, Hooghly, Cossey, Bhagirathi and Mayurakshi, etc.

Complete details about zamindari/test reilef embankments do not appear to be available with the State. They have, however, supplied information, partial in some aspects, about 36 embankments in Murshidabad, 30 in Nadia, 312 in 24 Parganas (North) and 61 in Midnapur districts. The total length of the 66 embankments in Murshidabad and Nadia districts is 478 km. The area protected by the 36 embankments in Murshidabad district is stated to be 77,310 ha. The population protected by 409 embankments in the districts of Murshidabad, 24 Parganas (North) and Midnapur is of the order of 6.69 lakh.

7.2.4 *Orissa*

About 3,000 km of test relief embankments are existing in the State. There is no single individual test relief embankment which protects an area exceeding 1000 ha. A Committee of Engineers has recommended the transfer to the Irrigation Department for maintenance, of 964 km of these embankments which conform to the Master Plan, satisfy the minimum required spacing, provide saline protection and do not interfere with natural drainage. The Committee also decided to abandon such of the test relief embankments which provide no direct benefits against flood but function as secondary protection.

Some details have been furnished, of works, which have not been superseded by embankments constructed under the flood control sector. The details indicate that in the Mahanadi basin there are 136 embankments with a total length of about 311 km affording protection to about 32,000 ha and about 2 lakhs of population in 237 villages in Cuttack district but excluding the villages protected in Puri district, for which information is not readily available. Out of the above, three embankments of a total length of 2.07 km on the Mahanadi/Tel in Kalahandi district are now proposed to be taken over by the Government and maintained to OAE (other Agricultural Embankment) standards. These embankments are for protection of cultivated land from flood waters.

Sluices have been provided in some of these embankments for the drainage of the protected area, while in some, there are spurs, bed-bars and revetments in certain places as protection against river scour and erosion. In case of some embankments, no improvement has been possible for want of funds though necessity for raising or strengthening or providing sluices has been felt.

In the Baitarni basin, there are 11 embankments with a total length of about 8 km protecting 1,300 ha of land and 4,300 population in 14 villages of Keonjhar district. These embankments are reported to have been recently transferred from the Revenue Department to the Irrigation Department.

In the case of the Vansadhara basin, there are four embankments with a total length of 4.25 km protecting an area of 615 ha and a populaion of 1,000 in six villages. In three of these, high filling reaches have been protected by rubble packing. In one (transferred from the Revenue Department), two sluices have been provided, ie., one for drainage and the other to irrigate about 80 ha.

In the Rushikulya basin, there are four embankments of about 6 km total length protecting an area of about 500 ha and a population of about 1,000 in four villages of Ganjam district. These are the test relief embankments transferred from the Rural Engineering Organisation (REO) Department to the Irrigation Department.

In the Bahauda basin, there are five embankments of 12 km total length protecting about 1,500 ha and a population of about 1,000 in five villages of Ganjam district. These are also test relief embankments transferred from the REO Department.

There is one embankment of a length of 0.09 km on the Tikira river, protecting 230 ha in a village of 800 in Sambalpur district.

As in the case of the Sunderbans area of West Bengal, private embankments primarily for reclamation of land against tidal inundation were also constructed in the deltas of the Mahanadi, the Brahmani and the Baitarni rivers.

7.2.5 *Bihar*

It has not been possible for the State to compile the full list of zamindari embankments though these are still in existence and have not been superseded. As per the available information, there are 4 embankments in Saran, 27 in Samastipur, 7 in Gopalganj and one in Palamau.

The following information is available in respect of the embankments which have since been taken over by the State.

Few small bunds constructed by zamindars *viz.* Charkavami to Narkatia (13 km). Charkavami to Sonbarsa (10 km). Islampur Tola to Manchu Tola (8 km). Ramnagar to Kamlakund (6.4) and Abhia Bazar to Budhuchak (11.2 km) exist along the left bank of the Ganga in the reach from Narayanpur to Kursela. Ex-zamindari embankment for a length of 28.5 km are scattered along the right bank of the Kosi in the reach from Trimohani to Kursela. Further, there are private embankments located in a haphazard manner and very close to the river on the same bank of the Kosi upto the confluence of the Bagmati and along the right bank of Bagmati in the reach Nagarpara to Badladghat. The approximate length of these embankments is 18 km.

The Chakurilal bund, a private embankment, was constructed for the protection of Laheriasarai town against flood spills of the river Darbhanga Bagmati. After the zamindari rights were extinguished, the care of this embankment passed on to the Revenue Department. Another private embankment known as Giddarganj bund was also constructed for the protection of Darbhanga Laheriasarai town. This bund was subsequently taken over by the Rural Engineering Organisation which has built a metalled road on the top of this embankment.

7.2.6 *Uttar Pradesh*

There are a number of zamindari embankments in the districts of Gorakhpur, Basti, Deoria and Azamgarh. Their number is 24, 37, 14 and 13 respectively, thus making a total of 88 in the State. The total length of these embankments is 425 km. Other statistics like area, population, number of villages protected, etc., are not available.

As per the partially available statistics, 12 embankments protect an area of more than 1,000 ha each, maximum by any single embankment being of the order of 4,000 ha. The maximum population protected by a single embankment is 50,000.

7.2.7 *Manipur*

Some embankments have been constructed by the Block Development Department under test relief programme. Some private bunds have also been constructed by certain individuals/cooperative societies for reclamation of land in the area affected by the flood waters of lakes. Some flood embankments have also been constructed with assistance from the Tribal Welfare Fund/Central Government for the development of areas inhabited by scheduled tribes and other backward classes. Some of these bunds have been superseded by new embankments constructed by the Flood Control Department.

According to the partial information received from the State Government, the total number of such embankments is 8 and their length 28 km. They afford protection to an area of 3,405 ha and a population of 28,000 in 20 villages.

There is no individual scheme which benefits more than 1,000 ha.

7.2.8. *Jammu and Kashmir*

The zamindari embankments, constructed by the beneficiaries on voluntary basis prior to 1950, were in the form of dowel bunds without any continuity at drainage crossings, as such they provided protection to small patches of land and that too in the case of very low floods. These have already been taken over by the Government, realigned, raised and strengthened from time to time to serve as protection against minor floods.

At places, where the alignment of the zamindari bunds has not necessitated any change, the dowel itself has been raised and strengthened. Where, however, the alignment had to be retired, the dowel bund was demolished by the time the new embankment got consolidated.

7.3. Performance/effect on the flood problem

7.3.1. In Uttar Pradesh the zamindari bunds were constructed to protect crop and population from floods. No details regarding separate assessment of damages are available. The State is of the opinion that such zamindari bunds which have not been superseded, are generally useful though most of these bunds need strengthening.

7.3.2. Bihar has a large number of major rivers and rivulets. The State considers that some of the zamindari embankments which were constructed along the minor rivers and rivulets have proved useful but a large number of these breach on account of inadequate section or inadequate free board. However, no separate assessment of the damages by breaches, overtopping etc., has been made.

7.3.3 West Bengal is of the opinion that these embankments have served their purpose to the extent expected of them. No separate assessment of the damage caused by breaches etc. is available. However, a rise in bed levels due to sedimentation of channels with consequent rise in flood levels, lack of proper maintenance and more intensive cultivation in the so-called protected areas have resulted in an increasing trend in the damages caused by breaches in these embankments.

7.3.4. In Orissa, it is considered that the test relief embankments decided to be taken over and maintained by the Irrigation Department, will provide protection from low floods. Having a crest width of 1.52 m and height not more than 0.91 m. they are considered useful only against low floods and give only partial relief. However, if constructed indiscriminately, they cause afflux and obstruct free flow of drainage. No separate assessment has been made of the damage caused by breaches, overtopping etc. As a rule, they are repaired by the Revenue Department each time there is a breach.

7.3.5. The Manipur Government considers that the embankments constructed under zamindari/test relief works have given protection against medium floods, benefiting about 3,000 ha of land. These have also provided an improved means of communication to remote areas which were otherwise inaccessible by any means of transportation. Some of these embankments have been overtopped resulting in serious breaches. A separate assessment of damages caused by breaches and overtopping has not been made.

7.3.6. On the whole, it is felt that, zamindari embankments did provide limited protection to areas intended to be protected. But these were found to be inadequately planned and designed which was natural, as these were the efforts of individuals, who had insufficient data and limited knowledge. Most of these embankments are sub-standard, aligned very close to the river banks, and subjected to frequent overtopping, breaches and erosion. Test relief embankments also are, by and large, of the same standard. Another drawbacks is that these embankments were not maintained.

We understand that in most of the States, it has now been decided that such embankments should be taken over by the Irrigation Departments for maintenance as well as raising and strengthening. Normally, there is a demand from the local people for maintaining, raising and strengthening of every existing embankment, no matter however sub-standard and badly located.

7.4. Past Committees

7.4.1. No committee/expert has so far been appointed to examine the effect of zamindari test relief embankments and similar other works on the flood problem in the States of Uttar Pradesh, Bihar and Manipur. In the case of Orissa after the transfer of the test relief embankments to the Irrigation Department, the Technical Advisory Commitee (TAC) of the State examined the condition and the effect of these embankments and decided to improve the useful ones to the OAE standards and to abandon those not considered useful. A recommendation has also been made to make the top of such useful embankments fit for inspection by moorum topping. Out of the 3,000 km of these embankments, about 964 km have already been transferred to the Irrigation Department. Only about half of the balance of 2,000 km is considered useful for retention. For improvement of these 2,000 km (i.e. 964+1000) of test relief embankments, the State TAC has recommended an approximate amount of Rs. 18.20 crores. Action on implementation of TAC's recommendation is, however, yet to be initiated.

7.4.2. In the case of West Bengal, the West Bengal Flood Enquiry Committee (1962) had, *inter alia*, suggested that the question of retention or otherwise of some of the ex-zamindari embankments should be examined by the Irrigation and Waterways Department of the State and as a matter of principle embankments along the river channels in lower Bengal should be discouraged wherever possible and should be retained where indispensable.

7.5. Maintenance

7.5.1. The maintenance of the zamindari embankments is not upto the standard in most of the States.

7.5.2. With the abolition of zamindari in West Bengal most of the zamindari embankments were automatically vested in the Land & Land Records Department and the responsibility of their maintenance lies with them. However, as this Department does not have an adequate technical organisation to accomplish this, a proposal has been initiated to transfer such embankments to the Irrigation & Waterways Department. Taking over the embankments as proposed, involves preparation of land plans and other paper work and provision of additional funds for maintenance of these embankments. This has not yet been done although some of the embankments are being maintained by the Irrigation and Waterways Department as contingent response to emergency.

It had been exceedingly difficult to maintain these embankments properly because of the defects such as poor conditions of the soil, improper alignments, insufficient heights and sections, absence of revetments in vulnerable zones etc. The consequent inundation of the fields by the saline tidal waters causes damage to standing crops. This lack of a sense of security has stood in the way of optimum utilisation of land particularly from the point of view of agriculture and flood protection.

A scheme namely the Urgent Development of Sundarban areas has been sanctioned at an estimated cost of Rs. 16.43 crores for raising and strengthening 2,120 km length of the existing embankments of inadequate sections and heights, retired embankments of 55 km length and constructing about 328 km of compartmental bunds and 322 hume pipe sluices for drainage of the protected area.

Besides this scheme, another scheme, namely Sundarbans delta Project Phase-1, estimated to cost Rs. 18.75 crores and serve an area of 492 sq. km., has been submitted to the Ganga Flood Control Commission. This scheme also is located within the area of Sundarban where the circuitous embankments already exist. The Phase-1 scheme provides for the closure of tidal rivers and a master embankment with drainage sluices around the protected areas. This would result in the existing embankments within the area becoming redundant and obstructive, they would therefore, have to be demolished. The Phase-1 scheme also envisages creation of a sweet water reservoir in the protected area. This will help reclamation of the area, prevention of saline inundation, proper drainage, etc. The Phase-1 scheme is a part of the Great Master Plan for the development of the Sunderban area prepared in consultation with Dutch experts. Implementation of the Great Master Plan in a single phase was considered too ambitious and it is proposed to be implemented in 3 phases, of which Phase-1 forms the first part. The other two phases are, more or less, of a similar nature.

Whenever it is decided to supersede a zamindari/test relief embankment, the portion in line with a proposed flood control embankment is made use of and brought upto proper section. The rest of the length is abandoned as demolition is considered to be too expensive.

7.5.3. In case of Bihar, the State Government took a decision in May 1976 that all zamindari embankments which relate to the main rivers should be taken over and maintained by the Irrigation Department. The maintenance of smaller embankments which were constructed under the framework of 'Fard-Ab-Pashi' (irrigation rights) and were useful, should be looked after by the Revenue Department to the extent that funds could be made available. The Revenue Department, however, does not have the necessary technical facility for maintenance of such works.

After the 1975 flood, the State authorities have framed and executed a scheme, namely, the Darbhanga Town Protection Scheme at an estimated cost of Rs. 120.89 lakhs for repair and strengthening of the Chakurilal and Giddarganj private embankment.

No superseded embankments have been demolished in this State. These zamindari embankments which fall in the alignment of the embankments constructed under the flood control programme are automatically merged with the main embankment and are, therefore, properly maintained in their improved sections.

7.5.4. In case of Uttar Pradesh, the bunds were transferred to the Rural Engineering Service Department after the floods of 1974; prior to this, these were being maintained by the Revenue Department. Since May 1977, the bunds have been transferred to the Irrigation Department which has the necessary technical facility to maintain them also. Generally speaking, demolition of zamindari bunds is not being done on account of opposition from the public.

7.5.5. In Orissa, the Irrigation Department has taken over the responsibility for maintaining those test relief embankments which are declared useful for providing flood protection without any interference to free flow of flood and drainage waters. This is on account of the fact that the Irrigation Department, which also handles the flood control works of the State, has the necessary technical facilities to maintain these embankments as well.

No special action or attention is considered necessary to demolish the superseded embankments since it is observed that due to the high rainfall, such embankments get eroded and disappear in course of time.

7.5.6. In the case of Manipur, the Government has not yet taken over the responsibility of maintenance of the unsuperseded embankments. However, if a serious problem arises or extensive damages are caused by breaches or overtopping, the Flood Control Department undertakes repair works of inescapable nature, purely, as a matter of public interest. There is no other Government department to look after the maintenance of such embankments. Neither is there any proposal so far for transfer of such embankments to the Flood Control Department. When some private bunds breached during 1977 flood season, the Department undertook the necessary repairs. It is reported that the question of fixing an agency to look after such embankments is under consideration.

While strengthening/improving test relief embankments or constructing new embankments, the original embankments are not demolished. They are widened or raised as the case may be. The sub-standard embankments are brought to proper standards and design. Economic considerations are stated to be the reason for this practice.

7.5.7. The position about Jammu & Kashmir has already been stated in para 7.2.8. which indicates that these embankments have all since been superseded.

7.5.8. According to the Ganga Flood Control Commission, no specific instances where zamindari embankments have aggravated the flood problem have been brought to their notice. On the other hand, there have been persistent demands for taking over the zamindari embankments under Government control so that these could be raised, strengthened and maintained properly.

7.6. The future

7.6.1. Uttar Pradesh has stated that these embankments have been recently transferred to the Irrigation Department, and an overall plan is being prepared to re-align, re-construct and strengthen them so as to fit in the overall strategy of flood control works or to supersede them. Bunds which are encroachments in the flood plain and are not considered desirable will be superseded.

7.6.2. In West Bengal most of these embankments, if not all, are of sub-standard design and construction and if these are taken over by the Irrigation & Waterways Department, it will be imperative on their part to re-align and remodel them. There is no plan to remodel all the embankments in the State as a whole. However, the Sunderban Delta Project is a programme of re-alignment and re-sectioning of embankments, closure of some of the creeks and provision of drainage sluices for the areas protected by circuit embankments. The project has not yet been taken up, mainly due to shortage of funds.

Since the abolition of zamindari, the work of maintenance of many ex-zamindari embankments and structures has devolved on the State Irrigation and Waterways Department. As stated earlier, most of these embankments do not satisfy the standards and specification of the Department and no funds are earmarked for their annual maintenance. The State has further expressed that on many occasions assets created by the State Home Department through Test Relief, Crash Schemes for Rural Employment and other forms of work are vested with the Irrigation and Waterways Department without allocation of the requisite funds for maintenance. Evidently, this results in further taxing the already meagre provisions

7.6.3. In Orissa, no proposal has been formulated to include the unsuperseded embankments as a part of the over-all plan of flood control. However, a preliminary study has been made and it has been examined how such embankments can fit into the Flood Master Plan of the State. It is felt that most of the test relief embankments should be abandoned as they do not fit into the technical requirements of flood protection embankments. Nevertheless, a final decision has yet to be taken by the State Government.

7.6.4. Manipur has stated that while preparing detailed plans for flood control in the valley, sub-standard embankments have also been taken into consideration and improvement/construction of such reaches is being taken up in a phased manner. A State Level Committee will also consider the necessity of superseding some of these embankments. Further, responsibility for maintenance will have to be fixed so that damages due to breaches/overtopping of these embankments may be reduced. Also, indiscriminate construction of private bunds etc. will have to be stopped by necessary legal action.

7.6.5. According to Bihar, the plan to replace or supersede embankments or to remodel them as a part of the overall plan of flood control, will be formulated as soon as a list of all such embankments with their details is compiled. The State is, however, of the view that renovation and re-alignment, where necessary, even of such embankments as are useful, will not be possible unless the State Government is given additional grants for the purpose.

7.6.6. Both the Central Water Commission and the Ganga Flood Control Commission are of the opinion that the State Irrigation and Flood Control Departments should carry out a critical review of all the zamindari and test relief embankments. Where these embankments fit into the overall planning, they should be incorporated in the State's flood control plan. Further, in future, test relief embankments should be constructed only where they can form a part of the overall flood control programme of the river. We have considered the various issues involved and recommend that as far as possible no new test relief embankments should be constructed unless these form part of the overall flood plan. Relief may be provided by raising and strengthening existing embankments.

We also agree with the Ganga Flood Control Commission that, while processing proposals for take-over, it will be necessary to keep in view the following aspects:

(i) Whether the area protected by the zamindari embankment is getting protection from any other flood protection scheme or not,

(ii) How far the existing zamindari embankment could be utilised in the new flood protection scheme contemplated for the area,

(iii) Which embankment or part of it or group of embankments cause aggravation of the flood problem in the area and what remedial measures will be necessary, and

(iv) How far the zamindari embankments could be utilised as ring bunds in the overall plan of flood protection in the area.

VIII EFFECT OF DEVELOPMENT WORKS AND ENCROACHMENTS

8.1. Introduction

8.1.1. In a developing country like ours, launching of development activities on a massive scale with the onset of Independence from 1947, was and continues to be an economic necessity for the general uplift of the country's teeming millions. During the last 30 years, therefore, there has, *inter alia*, been a significant expansion of the network of rail/road communication systems, canal systems, tanks, embankments, large industrial and residential complexes, etc. While encouraging results have, no doubt, been achieved in the respective fields, these works have, sometimes, affected free drainage thereby aggravating the flood problem. Rain water or spill water from channels had an unobstructed flow to rivers/channels previously. Also, the infiltration index or the amount of rain water seeping into the ground has decreased due to occupation of the land by structural works and large-scale urbanisation. As a result, stagnation or retardation of the flow of water has increased This has also resulted in higher flood peaks.

8.1.2. Developmental works are the responsibility of different agencies. Therefore, cross drainages across works like railway lines, roads, canals, etc., are designed and implemented by the concerned departments. It is not that always hydrological and drainage data are available at every location. Also usually there is a tendency to economise on construction. It, therefore, sometimes happens that enough capacity is not provided in the cross drainage works. This leads to drainage congestion and arguments amongst the departments concerned, both Central and State.

Embankments usually constructed by the States result in higher flood flows and raise afflux under bridges of railways, national highways, etc. This again is a cause of arguments between the departments.

Encroachments into the flood plains and riverbed cultivation even into smaller drains cause obstruction and flooding. Even where provisions exist to enable drainage channels to be kept clear, implementation is almost non-existent.

The Government of India, in the Ministry of Railways constituted the Khosla Committee of Engineers in 1957 to investigate and review the methods of estimating the maximum flood discharge from catchment areas in order to determine the waterway and other connected factors required in connection with the design of bridges. One of the important recommendations made by the Committee was rationalisation of the formulae for the calculation of peak floods so that all departments concerned could work out waterways with the same formulae; this was intended to obviate differences in designs.

Committees of Engineers were constituted in each State to, amongst others, examine the adequacy of waterways. In some States, these Committees are also given the responsibility of similarly examining cross drainage works for roads, canals, etc.

As already stated, there is sometimes disagreement between the Central Departments like Railways, National Highways and the States about the waterways provided by either party which may affect some structures owned by the other party. In order to settle such disputes, a Standing Committee under the chairmanship of the Chairman, Central Water Commission, has been set up.

8.2. Areas affected by highways, railways, etc.

8.2.1 Drainages have not received adequate attention and have been allowed to get silted up and choked for lack of maintenance. They are also under the control of various departments, like the Revenue, Irrigation, etc,. and the lack of maintenance is usually attributed to paucity of funds.

Embankments on roads, railways, canals, etc., obstruct natural drainage and quite often the cross drainage works are inadequate in numbers and capacity. As a result of inadequate drainage under such embankments, upstream areas are usually a sheet of water of varying depths during the rainy season. Such pools of water damage land, upset communications and are, in general, a health hazard.

Situations like these lead to complaints by one department against another and quite often by the State against the Central Departments like the Railways and National Highways. Sometimes, mutual consultations lead to agreed solutions and implementation; at other times, the arguments are prolonged and works are delayed.

8.2.2. *Reports from the States*

Assam

In Assam, there are many cases of inadequate waterway in the railway and road crossings across the numerous tributaries and sub-tributaries. However, there are only four cases for which certain investigations have been carried out and reasons for acute flood hazards/congestion have been ascertained. These cases are discussed below:

(i) Railway bridge crossing at Kumatiya river: After the earth quafle or 1950, the river course was seriously disturbed and the river flowed in four channels *viz.*, Moridhol, Jaidhol, Kumatiya and Sampara. After the floods of July 1974, the Jaidhol joined Kumatiya. Since investigations indicated that the natural tendency of the river was to split into channels, training measures were adopted to stabilise the river system. During the floods of 1975, the approach of this bridge was breached and considerable adjoining area was submerged. Investigations revealed that the maximum discharge through this river system was of the order of 2210 cumecs. The computed discharge for a flood frequency of 50 years is of the order of 2323 cumecs. But the existing Railway bridge across Kumatiya was designed for a discharge of 1643 cumecs only, which is very low and the cause of obstruction to the river flows.

(ii) Road bridge crossing at Kumatiya river: The approaches of State P.W.D. road bridge, a little distance downstream of the above Railway bridge with the same waterway, were washed out during the 1975 floods, thereby establishing the necessity for increasing the waterway.

(iii) Puthimari river: There are four specified areas which experience distress frequently near the Railway bridge across the Puthimari river:

(a) Dhulabari at 13.9 km in the L/B of Puthimari embankment from Mukaldonga to Rangia-Gauhati Railway line.

During July 1970, the above embankment was overtopped in many places. The embankment was also breached by percolation and seepage at Dhulabari. This resulted in inundation of cultivable area of about 4 sq. km. This area is on upstream of the Railway bridge.

(b) Bagribari on the R/B of Puthimari from Habibari to Rangia-Gauhati Railway line.

Due to the reasons stated earlier, paddy fields of about 8 sq km. upstream of the railway bridge was damaged.

(c) Athara village from 18.95 km. to 19.1 km. of Puthimari L/B embankment from Rangia-Gauhati Railway line to Rangia-Arunachal Railway line.

There are three crossings, namely, (1) N.T. Road Bridge, (2) N. H. Bridge, and (3) N. F. Railway Bridge. Due to floods in the Puthimari during the month of July 1972, there was significant afflux at these crossings. Heavy piping and leakages took place along the embankment in the reach, resulting in a breach at Athara on 29-7-72, which affected an area of about 20 sq. km.

(d) Solmari from 13.6 km to 13.645 km of Puthimari L/B embankment from Mukaldonga to Rangia-Gauhati Railway line.

For the same reasons as stated above, the above embankment breached at Solmari on 28-7-72. The breach occurred 1 km. upstream of Railway bridge affecting an area of about 8 sq. km.

(iv) Pagladiya River: There are two areas which experience distress conditions frequently. One area comprises mauzas such as (a) Uttar Barbhag, (b) Pub-Barbhag and (c) part of Khata. The other area comprises part of Khata Mauza including Nalbari town, Batbagila Mauza and Bahjini Mauza.

As regards remedial measures, the Railway Department is examining the problem for providing increased waterway in their Railway bridges. The Assam P.W.D. is also considering similar action in consultation with the Ministry of Transport, Government of India.

The Ministry of Transport have stated that generally hydraulic details pertaining to existing nearby bridges belonging either to the Railways or to the State Highways are obtained while formulating proposals for construction of bridges on National Highways. Though no formal consultations are held regularly, the hydraulic details obtained from Railways/State Highways are given due consideration in fixing waterways for bridges on National Highways On the other hand, flood protection works are generally carried out on their own by the State without consulting the National Highway authorities.

Bihar

A list of the sections of the National Highways and State roads affected by submergence and distress due to severe floods experienced during the years 1974, 1975 and 1976 is enclosed *vide* Annexure 8.1.

The Ministry of Transport have pointed out that tagging of Mahananda flood control embankment to N. H. 31 in km 423 was done by the State Irrigation Department without consulting them and without paying any attention to the objections raised; as a consequence, the N.H. gets overtopped by flood waters. Raising of the N.H from km 423 to km 427 is necessary and the proposal is with the Irrigation Department for approval.

Orissa

The following N.H. bridges/crossings cause distress frequently:

(i) Vented causeway of National Highway crossing of the Brahmani spill at Kuakhai.

(ii) National Highway bridge across the Kansbans river.

(iii) Panchapda nala bridge on N.H. near Balasore.

(iv) National Highways across the Burhabalang near Balasore.

(v) National Highway bridge across the Rushikulya, under construction.

Distress is also caused at the following State road crossings:

(i) Burhabalang bridge on the State Highway near Baripada.

(ii) The State Highway bridge across the Bhargavi at Chandanpur.

(iii) Bridge on the State Highway, Pipili—Puri, on the Tarakaj to Ganganarayanpur drainage nala, at Sakhigopal.

(iv) Causeways on the State Highway at Mahulapali and Jamseth near Pankmal.

The State Government has made investigations into the causes of distress by constituting a High Power Committee, the recommendations of which have been brought to the notice of the concerned authorities for implementation.

Rajasthan

Areas situated in the upstream of Agra-Jagner Road bridge across the Utangan river frequently experience distress. Here the width is less and height excessive, as a result of which excessive heading up during high floods takes place. This results in submergence of areas in Rajasthan and interferes with the flow conditions of the Gambhir (Utangan) river in a very long stretch on the upstream.

A list of the sections of National Highway and Railway crossings which experience distress frequently is enclosed *vide* Annexure 8.2.

In so far as the State Government is concerned, no detailed investigations have been made for the causes of frequent distress at the places listed.

The Ministry of Railways have pointed out that the outflow from Khanwa bund is affecting the Railway bridge downstream. In regard to another similar problem, they have pointed out that "The State Government is insisting on the Railways to increase the waterway at bridge No. 74 on Utangan river on Bayana-Agra Fort Section (at km 37/12-15). The reason for railway bridge not carrying the full discharge of Gambhir river is the restriction of the waterway of U.P. road bridge downstream of this railway bridge and consequent silting of the Utangan river. In fact, one span of the railway bridge is filled with earth up to bottom of the girder. Since the road bridge is narrow, the river flow by-passes this railway bridge and flows into Khavi river on the Fatehpur Sikri. Against the discharge of 4533 cumecs at bridge No. 3 on the same Gambhir river on the Sawai Madhopur-Bharatpur Section, the bridge only passed 1700 cumecs. The correct solution of the problem is to widen the road bridge to the downstream of the Utangan bridge. The U.P. Government is not responding to the requests of the Railway and the Rajasthan Government."

The Ministry of Transport have stated that no new flood protection works which might affect National Highways have been constructed by the State Government/Railways without consulting the National Highway. However, there are locations where the existing flood protection works and the irrigation system affect the safety of the National Highways. Two such major locations are as follows:

(i) National Highway No. 11 in the vicinity of Bharatpur.

(ii) National Highway No. 15 at its crossing over the Luni river.

The Ministry has stated that, "As regards the flooding of N.H. 11 in the vicinity of Bharatpur town, it may be mentioned that the existing National Highway is a low-level road traversing through the basin of Banganga and Gambhir rivers. Marginal bunds have been constructed across the drainage channels at isolated reaches. There are a number of canals taking off from the river system. In addition, there is a system of inundation irrigation, aided by a large number of irrigation bunds on either side of the National Highway. The cross-drainage works across the National Highway are limited in number. These structures have got gates which are operated by the Irrigation authorities during floods to manipulate the course of the discharge. During severe floods, many stretches of the National Highway get overtopped. Though the National Highway authorities would be willing to raise the road and provide adequate cross-drainage structures to balance the flow of water and keep this artery of traffic free from interruption, such a solution has not so far been evolved because the irrigation authorities are not in a position to supply maximum impounded levels in the irrigation tanks. This matter is being pursued with the State Irrigation authorities and it is hoped that an equitable solution would evolve in the near future."

In addition, the following road sections of National Highways experience some overflowing due to local irrigation works:

(i) Jaipur-Delhi section of N.H. 8 near Jaipur and Amber.

(ii) Jaipur-Ajmer Section of N.H. 8.

To sort out the problems, discussions were held with the Irrigation Department.

The Roads Wing are aware that a coordinated approach amongst the Irrigation Department, Railways and the National Highway authorities is necessary. Efforts in this direction are being vigorously pursued. A reference to State Irrigation Department and Railways is made by the State P.W.D. who is incharge of State roads and National Highways, as and when necessary.

Uttar Pradesh

Frequent distress is experienced at the bridges under the N.H. No. 11 (Agra-Jaipur-Bikaner Road) in Agra district, particularly at the crossing of the western depression drain of the Irrigation Department. Between 1966 and 1976, flooding has occurred four times in the last 7 km of this road in U.P.

Over 400 major bridges of over 30 m in length each, have been constructed by the U.P. P.W.D. since Independence. Adequate waterways have been provided in these bridges so as to ensure that afflux is not more than 30 cm. However, a large number of old bridges still exist on roads that have smaller waterways. At some of such bridges, dips exist in the approaches to pass high discharges while at other bridges there are none and distress occurs at such places due to excessive afflux during floods.

Investigations have been made in the cases referred to above and proposal for increasing waterway is under consideration of the M.O.S. and T. and CWC as it is linked with modifications of the Western Depression Drain. A list of the sections of National Highways and State Highways which experience distress frequently during floods is enclosed *vide* Annexure 8.3.

As regards distress areas connected with State roads, proposals for increasing waterways are included in the State Government Budget from time to time and implemented according to availability of funds.

Railways, on the other hand, have pointed out that remodelling and widening of Goverdhan Drain has been done without their consent.

West Bengal

The road-cum-railway bridge over the Teesta near Jalpaiguri has been a point of much controversy regarding the adequacy of the waterway. The controversy had its origin during the 1968 floods when the existing waterway measuring 595 m fell far short of requirements and numerous breaches occurred in the embankments causing large-scale damage. The C.W.P.R.S., Pune and the River Research Institute, West Bengal came out with almost identical figures of 1311 m (minimum). Waterway has been provided to the extent of 915 m but no flood of the magnitude of 1968 flood has occurred since then and it remains an open question how this bridge will fare if such an occasion arises again. A special committee was constituted to go into the details for Teesta bridge and its recommendation has been implemented. The matter in respect of the Torsa and Alipurduar is still under consideration of the State Committee of Engineers.

Drainage congestion in Alipurduar town:

There has been a case of chronic drainage congestion in the town of Alipurduar, district Jalpaiguri due to construction of the broad gauge railway line. The drainage of the town is usually effected through the river Kaljani. But when the river Kaljani rules high during floods, there is a backflow instead and the water spills and spreads over the eastern portion of the town and results in waterlogging and consequent distress. A suggestion for an additional culvert at a suitable place for effecting drainage into the river Nonai has not been accepted by the Railways.

Rail-*cum*-road bridge across Torsa:

The existing rail-*cum*-road bridge at Ghughumari, in Cooch Behar district has four spans of about 46 m each, totalling 183 m. However, two Railway crossings at the same river upstream at Hashimara and Pundimari have a span of 412 m each. Therefore the waterway at Ghughumari bridge is inadequate. But the case for extension of the waterway of the bridge has not been agreed to by the Railways.

Haryana

Cross drainage provided under the roads had so far proved to be sufficient to drain normal flood water. The floods of 1977 were however, of unprecedented nature which caused widespread damage to the road system. The Flood Advisory Committee submitted a report. The situation is being remedied in the affected areas now by providing cross drainage works and by raising the formation level of roads. It is expected that with the increase in number of cross drainage works, the problem of flooding and breaching of roads will be solved to a large extent.

The capacity of Mangeshpur Drain near Bahadurgarh (under Delhi-Hissar Road) which, caters for the discharge of Mangeshpur drain, West Jua drain and Pakasma Drainage system, has proved inadequate. Water spilled, and overtopped the road. Action to get its waterway increased is being taken.

The Northern Railway have, however, reported serious problem of flooding of railway track and bridges near Khalilpur on Delhi-Rewari Section due to construction of bund near village Malehara on this section. According to them, this bund was constructed in 1975 and has disturbed the pattern of flow of the Sabi Nadi causing excessive flood towards Khalilpur, resulting in a serious situation.

Tripura

It is stated that the flood problem at Rajbari area of Dharmanagar Sub-Division has now aggravated after construction of about 18 km of rail line.

Other States..

The States of Andhra Pradesh, Gujarat, Haryana, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Punjab and Tamil Nadu have not reported any specific areas which experience distress frequently at Railway and/or National Highway crossings or even State road crossings.

8.2.3. *Views of the Railways and Ministry of Shipping and Transport*

Ministry of Railways

In case of "specified" bridges, the Railways carry out annual surveys of the rivers before the monsoon; these extend up to 3 km upstream and 1 km downstream to get a general idea of the efficiency of their training works. The Western Railway reported the case of bridge No. 74 on Utangan river (referred to above). The South-Central Railway have reported the following two cases:

1. Railway bridge across Wyra (Bridge No. 714 at Km 526/10-1 on Kazipet-Vijaywada Section).
2. Kattaleru Railway Bridge (Bridge No. 727 at km 541/7-8).

Stand taken by the Railways:

In both the cases, the recommendations of the Expert Committee set up under N.G.K. Murti to study floods and drainage problems resulting from severe cyclonic storm have been implemented.

The Railways have stated that while on their part, they have implemented the recommendations of the Expert Committee, the Andhra Pradesh Government have not taken any action to implement similar recommendations of the Expert Committee in respect of the PWD tanks; as such, they have referred the matter to the Central Water Commission.

The Railways have also claimed that no case of adverse effects like erosion and change of river course caused by railway bridges has been brought to the notice of any Zonal Railway by any State Government.

Ministry of Shipping and Transport

The N.H. authorities have stated that no general review of waterways of National Highway bridges has been necessitated as a result of the newly evolved formula, except, some specific cases where inadequacy of waterways was reported and where replacement of old bridges was necessary. Therefore, very little information has been supplied by the various N.H. units in the States. Details of the new formula are given in clauses 103 (Determination of Design Discharge) and 104 (Determination of Linear Waterway and Effective Linear Waterway) of Section I of the Code of Practice for road bridges (IRC Standard 5—1970) published by the Indian Road Congress. These are enclosed *vide* Annexure 8.4.

The Ministry has pointed out that, while fixing waterways for their bridges, they consult the Railway Authorities as they did in the case of the bridge across the river Yamuna at Kalpi on N.H. 25 which is just upstream of the Railway bridge. But they complain that the Railways do not follow this practice for which they quote the example of the Railway bridge across the Narmada near Broach where the level of the approach embankments was raised by the Railways without consulting the Highway Authorities.

The replies received from Bihar and Karnataka units of the N.H., however, mention that mutual consultations are held

8.2.4. *Need for coordination*

From the replies received from the various States, 8 out of the 9 Zonal Railways and an assortment of field units of the Roads Wing of the Ministry of Shipping and Transport, it is apparent that there is considerable lack of coordination amongst the various departments undertaking the structural works. Even among the different departments of the same State itself, there is scope for more coordination.

8.3. Past Committees

8.3.1. *Khosla Committee*

The Khosla Committee of Engineers, 1957 was primarily required to indicate measures to ensure safety of Railway bridges against failure of 'Railway affecting' works like embankments, tanks, canals, etc., besides suggesting design criteria, principles, formulae and methods of determining maximum discharge for the design of waterways for bridges, extent of bed scour for foundations, afflux for free board, and training works, etc.

The principal recommendations of the Committee, *inter alia*, were as under:

> "The 'design-flood' or 'design-discharge' (the discharge for which the waterway is to be designed) should be the maximum flood on record for a period of not less than 50 years. Where adequate records are available, extending over a period not much less than 50 years, the 'design-flood' should be the 50-year flood determined from the probability curve prepared on the basis of the recorded floods during that period. In cases where requisite data are not available for particular streams, as for bridges on new lines to be constructed the 'design-flood' should be based on the highest recorded flood in the neighbouring or other catchments of similar size and ground and meteorological characteristics".
>
> "A Cell should be established in the Railway Board under an eminent Bridge Engineer————to collect, systematise and analyse all the voluminous data————and establish values of coefficient in an empirical formula to be evolved. This will also provide necessary liaison between the Railway Board, Central Water & Power Commission, India Meteorological Department and the Roads Wing of the Ministry of Transport.————
>
> In order that the work of these four wings be carried out to the best advantage, there should be a Co-ordinating and Planning Committee, consisting of the heads of these Wings with Director, Bridge Engineering, Railway Board, as Chairman.————".

The Research Design and Standards Organisation of the Ministry of Railways have brought out a report titled "The Determination of Maximum Discharge for the Design of Waterway of Bridges", in which evolution of a unified empirical formula applicable to the whole country has been attempted, with the idea that the range in value of co-efficient 'c' in the formula be reduced to the minimum. Based upon analysis of observed data in selected catchments for a number of years, a map of India was prepared and block values of coefficient were plotted. However, the limitation of this approach has been spelt out.

The special cells recommended by the Khosla Committee have been set up in the Ministry of Railways (RDSO), in the Central Water Commission (Flood Estimation Directorate, now known as Directorate of Hydrology—Small Catchments) and in the India Meteorological Department (Hydro-Met Division). The Ministry of Shipping and Transport (Roads Wing) have not set up any cell so far for "want of funds".

The Planning & Co-ordinating Committee, as recommended by the Khosla Committee has been constituted. It consists of Members from Ministry of Railways (RDSO), C.W.C., Ministry of Shipping & Transport and I.M.D. A number of publications have been prepared, based upon the data collected.

The Railways have so far gauged 240 sites all over the country (out of the 360 allotted to them) and collected data on rainfall and discharge for an average of 5 monsoon seasons at each site. Sixty-five sites are being gauged at present. Daily stages are being observed during the monsoons at these 240 sites, to obtain stream flow records, for use in frequency studies. The analysis of the large volume of data collected is being carried out mainly in the Directorate of Hydrology (Small Catchments) in the Central Water Commission. So far, a report on the hydrological studies for lower Gangetic Plain has been issued and work on a report on the Lower Godavari Basin has been almost completed.

A number of zonal Railways have carried out review of waterways of bridges as recommended by the Khosla Committee. It is found that out of the 6754 bridges reviewed, 1325, *i.e.*, about 20 per cent have been found to have inadequate waterways.

No reply has been furnished by any Railway as to whether there are any cases of discharge observation sites where design flood levels have been reached/exceeded at a discharge lower than the designed one.

The Ministry of Transport was assigned 100 catchments where gauge-discharge data on National Highway bridges was to be collected. They have not been able to do this work for "want of funds". The design of waterways is being done by them as per IRC Bridge Code Section I. According to the Ministry, no general review of waterways of National Highway bridges has been necessitated except in specific cases where inadequacy of waterway was reported and replacement of old bridges was necessary.

The report published by Central Water Commission entitled "estimation of design flood peak (a method based on unit hydrograph principle) for 50-year return period flood" has been brought out. The Planning & Co-ordination Committee has approved this report and it is being circulated among the various railways by the RDSO.

8.3.2. *Technical Expert Committee, North Bihar*

The Technical Expert Committee on Drainage and Waterways of Railways and Road Bridges in North Bihar was set up in 1965:

> "(i) to study the effect of the railways, canals, roads and embankments on the drainage of North Bihar including the regime of major river systems, and (ii) to examine in particular the adequacy or otherwise of the waterways provided under railway and road bridges, and to suggest improvement in the existing waterways under railway and road bridges."

In its Report in 1967, the Committee concluded that the main causes for the drainage congestion are:

> "Inadequacy of the waterways of bridges to cope with flood discharge resulting in heading up, and thereby increasing the duration and depth of inundation of the countryside upstream of the bridge...."

The Committee listed the effect of various works on drainage of North Bihar and general remedial measures.

The Bihar Government has stated that this report has been taken into consideration in framing proposals of new bridges but extension of old bridges has not been carried out partly, because of non-availability of funds. The Irrigation Department have provided for implementation of some of these recommendations in their Master Plan for flood control in Bihar.

मेव जयते

8.3.3. *North Bengal Expert Committee*

The North Bengal Technical Experts Committee (1970) determined the causes of the 1968 floods as "considerable development in the North Bengal region since 1950, particularly in regard to the construction of National and State Highways, Railways, marginal embankments and other development works. These works have prevented, to some extent, the spread of flood waters which would have occurred during the floods prior to the construction of these works, thereby moderating the flood discharges."

It recommended a design criterion for road and railway bridges.

The Chief Engineer (Design and Research), West Bengal, I & W Dte. has circulated a memo [Ref. Memo No. 7225 (19)/(6)-CI dt. 2-8-76] spelling out guidelines to enforce a uniform procedure for examination of cases regarding waterways etc. referred by other Departments.

8.3.4. *Lower Damodar Committee*

In the opinion of the Committee on Flood Control and Drainage in Lower Damodar (1972), the causes of flood and drainage congestion in the lower Damodar region were:

> "Over the last half a century, it is reported that large areas of tidal basins were reclaimed near Ghatal. The result of encroachment of the tidal basins has been to deteriorate the outfall tidal channel of Rupnarayan river from Buxi to Geonkhali. This effect of reclamation of tidal basins is often overlooked and forgotten.
>
> The construction of the four reservoirs by the D.V.C. at Tilaiya, Konar, Maithon and Panchet Hill with one of the objectives as flood control, led the laymen to reclaim and cultivate the lowlying areas of the lower Damodar Valley even in the monsoon.
>
> The modern publicity media together with the increase of density of population in the lower Damodar region aggravated the feeling of injury due to floods."

The Committee recommended that:

> "The efforts for arresting further deterioration of the Rupnarayan from Buxi to Geonkhali may be made by:
>
> (a) Prohibiting further encroachment into the tidal basins and the tidal flood volume;
>
> (b) dredging and cutting pilot channels in the sensitive reaches or bottlenecks identified in the hydrographic survey and studies of flood tide and ebb tide; and
>
> (c) annual maintenance dredging of, say, 1 million tons per year to start with for being reviewed periodically every 5 years for increasing, if necessary."

8.3.5. *Other Committees*

Effect of developmental works, encroachments into drains and flood plains and increasing the waterway in rail and road bridges have also been mentioned by some technical bodies.

The High Level Committee on Floods (1957) has stated:

> "Even when flooding is not due to excessive precipitation, inundation can occur on account of obstruction in the stream. Inadequate waterway at road and rail crossings or other encroachments aggravate flooding by causing afflux. The area between the Gandak and the Burhi

> Gandak is drained by innumerable small drains. These drains are interfered with by local people for irrigation or fishing. Such artificial interference with the drainage system of these rivers, when in floods, accentuates the flood problem. Moreover, in these two areas, there are a number of low-lying depressions which do not get drained out for a long time."

The H.L.C.F. while reviewing Statewise problems in Vol. II of its Report, made some significant observations and recommendations on this subject.

The Central Flood Control Board, now merged with the Irrigation Ministers Conference, had debated the problem of accentuation of flooding by inadequate provision of waterways under railway bridges and culverts as well as the sharing of costs of providing new bridges or increasing waterways as early as at its 5th meeting held on 21-6-1956.

The Ministers Committee on Flood Control (1964) recommended:

> "Widening waterways in railway and road bridges should be taken up more vigorously in Bihar.
>
> To settle disputes about sharing of costs between flood control departments on the one hand and railways and highways departments on the other, the Committee recommends that in the case of disputes with railways, a Standing Committee should be constituted with the Chairman, C.W. & P.C. as the Chairman, and the concerned railway Chief Engineer and the State flood control Chief Engineers as Members, to which such disputes should be referred. The decision of this Standing Committee should be considered as binding on the parties to the disputes. A similar Standing Committee should be constituted with the representative of the Union Ministry of Transport (Roads Wing) taking the place of Railway Chief Engineer."

The Ministers Committee on Floods and Flood Relief (1972) suggested that necessary steps should be taken to enable suitable legislation in the States where legislation empowering State Governments to prevent encroachments into rivers and drainage channel did not exist.

In its Report, the Irrigation Commission (1972), *inter alia*, made the following observations:—

> "Roads, railroads and canals cause obstruction to drainage in many places, because their structures are designed with an eye to economy, with the result they cause an afflux in water levels and create congestion. At road crossings most often only causeways are provided, which cause considerable afflux at times of floods, just when it is essential for drains to function efficiently.
>
> Cross bunds are often put up across drains, sometimes with the permission of the authorities and sometimes without, to divert or pump out water for Irrigation or to facilitate navigation or fishing. Generally, these bunds are not entirely removed after they have served their purpose. As a result, the drains deteriorate and their normal functioning is affected.
>
> We would like to draw pointed attention to the need for examining the waterways at bridges on roads and railway embankments, and cross drainage structures across the canals in order to make them adequate for the purpose of preventing under afflux. Particular attention should be paid to the improvement of the waterways in the causeways across drains, so that they cause the minimum obstruction to drainage.
>
> Frequent inspections by departmental officials are essential to ensure that drains are not middled with unauthorisedly and their functioning obstructed. When obstructions are permitted, it should be ensured that these are completely removed before the monsoon."

The Working Group on Flood Control (1978) has suggested that:

> "Certain areas on either side of the existing and proposed drains (including rural drains) should be declared as green belts where no building or other activity should be allowed. This will not only facilitate improvement of these drains in future for taking discharges on account of growing urbanisation, but will also help in minimising the damage due to drainage congestion whenever rainfall of higher frequency than designed is experienced. These green belts at suitable locations can also be developed as parks and gardens."

Some of the important recommendations of the Working Group for evolving an Integrated Action Plan for Flood Control in the Indo-Gangetic Basin (1979) *inter alia*, include:

> "Immediate action should be taken to relocate habitations which are in the river beds or within embankments or as encroachments on natural drainage channels. Even if cultivation is unavoidable in danger zones, abadi sites should be outside the river beds.

> Unplanned construction of roads, embankments, buildings, housing colonies, without reference to the topographic conditions and natural drainage and floodways should be avoided. All construction in flood prone areas should be scrutinised by a Flood Zone Authority. On all existing constructions, cross drainage should be provided.
>
> The Irrigation Act should be amended or implemented rigorously to prohibit future settlements within the embankments and encroachments on rivers and natural drainage channels."

Circulation of the Flood Plain Zoning Bill in July 1975 by the Department of Irrigation, Government of India to the various States is a step in the right direction for dealing with the problem of encroachments in flood plains, drainage, etc., and regulating developmental activities in these areas. The bill has not yet been adopted by all the States.

Apart from the above-mentioned important Committees, some Committees were also set up by the States.

It may, thus, be seen that various Committees and discussion forums have pointed out the inadequacy of waterways as one of the main reasons for flooding/drainage congestion and have, therefore, unequivocally advocated increase in waterways in bridges, culverts, sluices, etc.

8.4. Measures for improvement—views on

8.4.1. *Coordination*

The need for provision of adequate waterways in rail and road bridges has been stressed by various Committees etc., that have dealt with the subject. In spite of this, the problem still persists.

The Ministry of Transport (Roads Wing) have stated that they fix the waterways of road bridges in consultation with the State Governments. It presumably means the P.W.Ds. of the State Governments and not the Irrigation/Flood Control Departments as would appear from the replies from most of the States stating that they are not consulted.

The States of Uttar Pradesh, Orissa, Manipur and Punjab have stated that they are not consulted by the Railways or National Highways for the fixation of waterways. The N.H. authorities do not consult the States in Bihar, and Rajasthan. The Railways refer the matter to the State Committee of Engineers in Bihar. The reply from Rajasthan about Railways is silent.

In Assam, the N.H. authorities consult the State and the Railways refer the case to the State Bridge Committee. Consultation is held in some cases in West Bengal, in all cases in Haryana, Andhra Pradesh, Karnataka and Tamil Nadu both by the N.H. authorities and the Railways. In Madhya Pradesh, the N.H. authorities hold prior consultations, but the Railways do not. The reply from the State of J.&K. about both the authorities is not clear. Kerala has neither any arrangement nor laid down any policy or procedure in this regard. Replies from the remaining States are silent on the subject.

As regards prior consultation by the State P.W.Ds. with the State Irrigation/Flood Control Departments, the position varies from State to to State. Prior consultations are held between the two Departments of the States in Assam (Bridge Committee), West Bengal, Orissa, Haryana and Punjab (State T.A.C.). There is no coordination between the two Departments in U.P., Bihar, Manipur and Madhya Pradesh. The position is not clear with regard to J&K, Rajasthan, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu and Keral.

We recommend that prior consultation by the National Highway authorities, State P.W.Ds. and Railways with the State Irrigation/Flood Control Departments should be made obligatory, if necessary, through proper legislation. To facilitate an expeditious check, it is suggested that the Government of India should evolve a guideline/checklist for the purpose of vetting of waterways by the State Irrigation/Flood Control Department. There is need to lay down a precise procedure for the purpose in view of some ambiguities in the Indian Railway Act and the Railway Code.

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8.4.2. *Fixation of waterways*

Rajasthan does not strictly follow Khosla Committee's recommendations.

Railways have evolved their own formulae for design discharges in pursuance to Khosla Committee's recommendations. National Highways follow Indian Road Congress Standard (5—1970)—Code of Practice for road bridges, Section I whose clauses No. 103 and 104 relate to the determination of design discharges and fixing of waterways respectively.

The most common practice followed by major States in alluvial rivers as well as National Highways and Railways is to fix waterways on the basis of Lacey's formula. Even the range of co-efficients is also the same.

The question of fluming the waterways determined on the basis of Lacey's formula along with the resultant afflux is a complex one and practices vary in different organisations/States. Only Uttar Pradesh has replied quantitatively that waterway is restricted to 60—70 per cent of the Lacey's waterway subject to the condition that afflux does not exceed 30 cms. National Highways have used term like "not to cause harmful afflux". West Bengal has used the word "harmless afflux", while Assam has used the phrase "to avoid creation of undue afflux". No other State has given any views regarding afflux.

Since waterways to be provided in the structures have to be governed by judicious hydraulic and economic considerations, the question of permissible afflux on a structure due to the fluming of rivers is an important one. This assumes an added significance in locations where a number of such structure like rail/road bridges, barrages, etc., are built in close proximity, as far example in Delhi, Lucknow, Srinagar, etc. In this case, the effect on flooding due to the cumulative afflux of all the structures may be appreciable. In this regard, therefore, RBA would like to endorse the following view taken *inter alia*, in a meeting of the West Bengal State Committee of Engineers, (based on Khosla Committee Report) and procedure adopted and circulated for identification of the Railway bridges and embankments having afflux of 0.5 m and above:

"(i) The effect of afflux on the submergence of the country should be specially studied. The area of land which will be submerged depends not only on the magnitude of the afflux but also on the slope of the country, both longitudinal and transverse. Again, the nature and value of the land and other property liable to submergence vary considerably from place to place. Accordingly, in certain cases even considerable submergence of the countryside may be comparatively harmless, while in other cases even a small afflux may cause excessive damage to property. In the circumstances no limit for the extent of depth and duration of such flooding and no hard and fast rules on the permissible limit of afflux can be laid down beyond the general statement that harmful afflux should be avoided as stated in the Khosla Committee Report.

(ii) However, so far as bridges on the new railway lines are concerned the standdard laid down by the Road Bridge Committee, viz., half the slope per mile of the country subject to minimum of 6″ (0.15m) and a maximum 1′-6″ (0.5m) be accepted. So far as the existing bridges are concerned each case should be considered according to its merit and the Khosla Committee's recommendation in this connection, be followed."

8.4.3. *Checking of waterways and State Committee of Engineers*

The urgent need for undertaking a review with the object of signaling out the bridges which aggravate the flood and drainage problems due to insufficiency of openings below them and to formulate proposals for remodelling such bridges was recognised as far back as 1955 when the Ganga and Brahmaputra River Commission recommended the setting up of Statewise Road Bridges Committees and Regionwise Railway Bridges Committees. Similar recommendations were subsequently made by the North West and Central India Rivers Commissions. The Statewise Road Bridges Committees were formed in the States of U.P., Bihar, West Bengal and Orissa and the reports of the Bihar, West Bengal and Orissa Committees were submitted to and approved by the Commissions. In the remaining States in which the Road Bridges Committees were not constituted, it was proposed to have the problem examined either by the Technical Advisory Committees of the States or by the State Committees of Engineers then set up at the initiative of the Railway Board.

In 1956, the Railway Board decided to set up Committees of Engineers in all the States with the collaboration of the State authorities, for the purpose of review of railway affecting works and allied matters. Since the review of the adequacy of waterways below Railway bridges was one of the functions assigned to the Committees of Engineers, it was, on a representation made by the Railway Board, not considered necessary to continue the Regionwise Railway Bridges Committees under the River Commissions. The regionwise Railway Bridge Committees were accordingly abolished.

The functions of the State Committee of Engineers, which consist of senior officers from the Railway(s), Public Works, Irrigation (Flood Control) Forest and Local Self Government Departments of the State Governments, as stipulated in the relevant notification, are:

(a) Exchange of information about schemes envisaged by any one department and likely to affect the working or safety of assets of another department and consequential safeguards to be adopted.

(b) Keeping upto date the list of railway affecting works, etc., naming the officials responsible for joint inspection of each such work immediately after monsoons and, if possible, also in advance of monsoons, and watching that the department responsible for proper maintenance of such works promptly carries out the necessary repairs....

(c) Assessing whether waterways, protection works, etc., provided by any department in an area severely affected by floods have proved to be inadequate and improvements needed for future.

(d) Coordination of related schemes of the various departments represented.

The Ministries of Railways and Shipping and Transport have said that matters relating to distress caused by inadequate waterways are discussed at the meetings of the State Committee of Engineers in the States of Andhra Pradesh, Assam, Bihar, Karnataka, Orissa, Rajasthan, Uttar Pradesh and West Bengal.

Various States and organisations have expressed their opinion about the effectiveness of this Committee. Uttar Pradesh considers this Committee as useful. According to West Bengal meetings of this Committee have partially helped in achieving the desired results. Andhra Pradesh has stated that decisions taken in these meetings are implemented. Rajasthan is of the opinion that meetings of this Committee have only helped in understanding the viewpoints of different departments on the local difficulties and solved only the minor issues. The vital issues remain unresolved.

According to C.W.C., "The State Committees of Engineers are effective in settling problems of local interest arising between the Railways and the State Governments, although for several reasons the solution of an individual problem is sometimes prolonged. The Committee provides a useful forum for local discussions and decisions at a technical level. The role of Central Water Commission in these Committees is only nominal, because of the problems being generally restricted to a local nature."

The Ganga Flood Control Commission is so far represented in the State Committee of Engineers of Bihar and West Bengal only, where inadequacy or otherwise of the existing ventways of Railways, National Highways and State Highways and other crossings mainly affecting the railway works are discussed. The G.F.C.C. have suggested that:

> "The scope of existing State Committee of Engineers is limited to examination of cases which affect the railway works. It needs to be expanded to include examination of all cases pertaining to determination of inadequate waterways in road and railway bridges keeping in view the existing as well as contemplated flood protection works. As a matter of fact it should be made mandatory on all departments of Central and State Governments to construct bridges on rivers only after obtaining clearance from the State Committee of Engineers or any other Technical Board set up for the purpose. There are numerous instances where the waterways being provided in railway and road bridges on the same river and in the same reach are considerably different, and it is time to initiate measures for regulation of this respect in a co-ordinated manner."

Most of the zonal Railways have stated that the State Technical Advisory Committees as well as the State Committees of Engineers are helpful in achieving the desired results. However, it has been stressed by some that these meetings should be held more frequently.

We find that there is still lack of coordination amongst the various departments. This leads to non-uniformity in the matter of fixation of waterways under cross drainage works, resulting in aggravation of flood and drainage problems.

We agree with the views expressed by the Central Water Commission about the effectiveness and role of this Committee. The Committee provides a useful forum for local discussions and decisions at a technical level. These Committees should be set up in States where they do not exist at present. We are in agreement and, therefore, endorse the G.F.C.C's. recommendation that it should be mandatory on all departments of Central and State Governments to construct bridges on rivers only after obtaining clearance from the State Committee of Engineers or any other technical board set up for the purpose.

8.4.4. *Standing Committee of Chairman, C.W.C.*

The above-mentioned Committee, in respect of Railway bridges, vis-a-vis, the flood control point of view in the States, was set up by the then Ministry of Irrigation and Power vide Resolution No. DW.V.516(4)/64, dated the 27th July, 1965 and further amended vide No. FC.26(1)/73 dated the 27th October 1973.

The Committee consists of:—

1. Chairman, C.W.C.—Chairman
2. Chief Engineer of the Zonal Railway concerned—Member
3. Chief Engineer of the State Government in charge of flood control—Member.
4. A representative of the C.W.C.—Member-Scretary.

The terms of reference of the Standing Committee as per the Resolution are:—

> "The Committee will go into cases where there is a dispute between the State Government and Railway concerning the cause(s) that have necessitated the provision of increased waterways (viz., modification of existing bridges or building new bridges) under Railway track. The Committee will examine the details

> and decide in the case of each bridge whether the increased waterway has become necessary due to any one or a combination of the following causes:—
>
> (a) natural causes like an established increase in the intensity of rainfall, natural changes in the course of streams, etc.;
>
> (b) change in the pattern of distribution of the run-off from a catchment area causes an increase in peak discharge through the concerned Railway bridge(s) due to flood control, drainage and Road and Irrigation Schemes or other works undertaken by the State Government;
>
> (c) original inadequacy of the bridge at the time of construction; and
>
> (d) any other causes.
>
> If the increased provision is necessitated due to a combination of more than one of the above causes, the Committee will also assess the proportion of the total increase in waterway attributable to each of these causes.
>
> Whenever a difference of view arises between the State Government and the Railway, the Chief Engineer, Zonal Railway or the State Chief Engineer concerned will submit a memorandum on the Railway's or State's case to the Chairman, Central Water and Power Commission with a copy to the State or the Railway authorities concerned. The Chairman, Central Water and Power Commission would then fix up a meeting to consider the matter. The decision of the Committee would be arrived at on the basis of the views of the Chairman of Central Water and Power Commission and the Chief Engineer of Railways and States concerned. Whenever a majority decision is not possible, the decision of the Chairman would be considered as the decision of the Committee. The decision thus arrived at will be binding on the Railways as well as the State Governments."

A similar resolution outlining the composition, constitution and functions of the above Committee in respect of National Highway bridges vis-a-vis the flood control point of view in the States, was issued vide erstwhile Ministry of Irrigation and power, Resolution No. DW.V.516 (4)/64, dated the 22nd December, 1965.

As far as the implementation and effectiveness of these Committees in fulfilling their objective is concerned, the position in the various States is enumerated below.

The States of Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Jammu and Kashmir, Karnataka, Kerala, Manipur, Orissa, Tamil Nadu, Tripura and West Bengal have reported that they have not so far referred any case for arbitration to the above quoted Standing Committee of Chairman, C.W.C.

The States of Andhra Pradesh, Gujarat and West Bengal have also quoted instances where they have been able to settle their disputes with the Railways and the National Highways by agreeing to share the costs of widening the existing structures without any reference made to the Standing Committee of Chairman, C.W.C.

Punjab has listed locations of 25 Railway bridges which they have referred to the standing Committee for deciding their apportionment of costs. Rajasthan has referred two issues. Decision on both the cases has been given by the Chairman, C.W.C., but it has not been implemented. Uttar Pradesh referred the case of increasing waterway of the Northern and the N.E. Railway bridges over the Gomti river in Lucknow, which was decided by the Chairman, C.W. & P.C (now C.W.C.). The case of reconstructing Railway bridge No. 85 of Kanpur-Tundla section in district Agra over Tapa Khurd drain has also been referred to by U.P.

So far, the States of Andhra Pradesh, Gujarat, Punjab, Tamilnadu and West Bengal have shared the cost of widening the waterway of Railway and National Highway bridges with these authorities. The rest of the States, like Assam, Bihar, Haryana, Jammu & Kashmir, Karnataka, Kerala, Manipur, Orissa, Rajasthan, Tripura and Uttar Pradesh have not shared any cost with the Railways or the National Highway authorities in regard to the widening of their bridges. While Madhya Pradesh replied that this subject pertains to Railways and the P.W.D. and not the Irrigation Department, no reply has been received from Maharashtra.

The Central Water Commission has given details of 18 cases referred to this Committee, Ministry of Railways have reported 23 cases Ganga Flood Control Commission has reported none and the Ministry of Transpprt has stated "no such cases", "replies to be given by the Chief Engineer", etc.

Views and suggestions

The present arrangements of the Standing Committee for the settlement of disputes regarding waterways with Railways and National Highways is considered satisfactory by the States of Bihar, Gujarat, Orissa, Punjab and Rajasthan, Kerala is of the opinion that the present arrangement may continue. The Central Water Commission consider that the Committee has been effective in settling disputes because the decision of the Chairman is binding on both the parties and a reference to the Standing Committee eventually leads to a solution of the dispute.

The States of Andhra Pradesh, Karnataka, Jammu & Kashmir, Madhya Pradesh, Maharashtra, Manipur, Tamilnadu, Tripura, the Ministry of Shipping & Transport and Ganga Flood Control Commission have not expressed any opinion about the effectiveness of the standing Committee.

West Bengal and different Zonal Railways have given mixed reactions on the subject.

Andhra Pradesh has, however, suggested that the cost and maintenance of additional waterways necessitated as a result of Government works like construction of embankments, canalisation, etc., upstream or railway|N.H. bridges, should be shared equally by the Railways, National Highways and Irrigation Departments as the benefits are shared by them.

Assam is of the view that the progressive development of the areas upstream of the bridge is natural. Such developments result in increased discharges to the rivers. The waterways of the bridges should be designed for the peak discharges which are expected from the catchment areas without getting any help from valley storage normally available in the areas upstream which in course of time will develop. As the works pertaining to National Highways and Railways are financed by Central Government, any aditional waterways and their maintenance should also be borne by them.

According to Bihar, flood control works, apart from preventing damage to standing crops and built-up properties, also help in preventing breaches in developmental works such as Railways and National Highways, many of which, in Bihar, are of a strategic nature. The State Government is of the view that not only the cost of construction and maintenance of adding additional waterways in the Railway bridges and the National Highway bridges, necessitated due to construction of flood protection and developmental works, upstream of Railway & National Highway bridges, be borne by the Government of India, but that the Centre should also bear the full cost of anti-erosion works arising out of construction of Railway and National Highway bridges on the rivers.

Gujarat has stated that consequent upon large-scale development of State works like roads, irrigation projects, etc., and Central Government works relating to Railway and National Highways, certain difference in opinion regarding waterways, is expected.

In this connection, the following suggestions are offered:

(i) If Railways/Highway bridges are existing and additional waterway to these crossings are required due to subsequent State Development Works like construction of canals, flood protection works, etc., complete cost of additional waterways should be borne by the State.

(ii) If State works like canals, flood protection works, drainage etc., are existing and additional waterways to crossings existing on these works are required due to subsequent developments of Railways/National Highways complete costs of such additional waterways should be borne by the Railways|National Highway Authorities.

(iii) Maintenance costs of such additional waterways should be borne by the concerned authorities of State Railways, or National Highways depending upon locations of such additional waterways on State works, Railways or National Highways for administrative convenience.

Haryana Government has observed that generally during the initial execution of Railway project or National Highway project, either the waterways at all the depression|drain lines are not constructed or if constructed, these are not of sufficient capacity to cope with the increased intensity of rainfall e.g. from 50 to 75 cm rainfall experienced during the past three years in Rohtak district. The State Government is of the view that the capital cost of such additional waterways should be shared between the State Government and the Railways|National Highways. The cost of maintenance should be borne entirely by the Railways|National Highways.

Jammu & Kashmir Government is of the opinion that in case the State Government is directly benefited as a result of providing additional waterways and maintenance thereof and if such works are not necessarily to be taken up by the concerned Central Government Department, the State Government may have to share the cost.

Orissa has suggested that whenever any new road project or improvement of National Highways or Railways are executed in the State, the full cost of making of additional waterways necessitated as a result of development works, construction of Railways and National Highway bridges should be borne by the concerned department.

Rajasthan is of the view that the development activity on the Railway and National Highway should also keep pace with the time and the cost of widening and maintenance of bridges, whenever found essential, should be borne normally by the Railways|National Highways as, otherwise, the question of sharing of costs leads to prolonged discussions and delays.

The Government of Uttar Pradesh is of the view that if waterways of the Public Works Department and Railway bridges are designed for inadequate design peak floods in any particular catchment, such bridges should be remodelled by the concerned departments as per recommendations of the Khosla Committee. If any catchment is added to the existing catchment for diversion of any water from another catchment, the cost of additional waterway necessitated on this account should be borne by the department causing increase in the catchment area. It may be mentioned, this cost will be for the loading and lanes of traffic in the existing bridge and if these are proposed to be increased, the extra cost on this account will be borne by the department in charge of the work.

West Bengal has observed that unless the Standing Committee is fortified with statutory powers and the will to act positively, the results may be quite discouraging. The State has suggested that where additional waterway is needed for development works upstream of the bridge, a high power committee consisting of the Chief Engineers concerned may be set up to go into the merits of each individual case and deliberate on the following points:

(1) Whether the development work upstream of the bridge has actually necessitated the additional waterway?

(2) If so, which authorities are the beneficiaries and what is the percentage of benefit accruable to each such authority.

(3) Recommendation for sharing of costs on the basis of benefits accruable to each authority.

Usually it will be easier if the maintenance cost is to be borne by the authority owning the bridge.

From a perusal of the list of cases quoted by the Central Water Commission, it is seen that the time taken for settlement of disputes by the Standing Committee seems to be very long and over 5 years in most cases. The CWC has suggested that the process can be expedited, if a time limit is fixed for the parties to supply replies/data failing which, the Chairman should be empowered to give an *ex-parte* decision. Implementation can be speeded up, if arrangements can be made to place funds at the disposal of the executing authority, in case it is not the owner of the structure to be remodelled.

Different Zonal Railways have expressed different views. The Northern Railway has stated that the present arrangement needs to be improved to arrive at decisions early by holding meetings at frequent intervals. It also wants a system to ensure implementation of decisions within a given period. The South Central Railway considers the present arrangement adequate. The Western Railway wants the Committee to be reconstituted on the experience gained by different parties. However, the Railway Board (Ministry of Railways) have not given any views on the subject.

Quoting certain reaches in Rajasthan, where National Highways have been affected by Irrigation structures, the Ministry of Shipping and Transport (Rajasthan Unit) considers it necessary that one Department does not go for any modification without the approval by the other. According to them, all bridges and cross drainage works across Irrigation canals on P.W.D. roads should be constructed by the P.W.D. only even if they are financed by Irrigation Projects as, on a number of occasions, they have not been constructed to the requisite standard and also byepasses were not maintained to the satisfaction of Highway authorities.

Based on the above views, we are of the opinion that the Standing Committee of Chairman, CWC, for settling disputes on waterways and sharing of costs, is an effective forum performing a useful role in this direction. The Ayog is in full agreement with the views expressed by West Bengal about statutory powers being given to this Committee and recommend that the Chairman, CWC, should have powers to fix time limits for the submission of replies by the parties concerned and, in case of default, to give *ex-parte* decisions.

8.5. Encroachments

8.5.1. Drainage channels, both natural and excavated, function mainly 3 to 4 months in the case of south-west monsoon and a couple of months in addition during the north-east monsoon in the case of States like Tamilnadu, Andhra and parts of Orissa. Since for the rest of the months, there is no flow in these drainages, there is a tendency towards encroachment into the same. The encroachment is sometimes by private people for cultivation of the drain banks, berms and even beds. Quite often, some States lease the rights of construction of temporary bunds for irrigation and/or fishing across these drainages in the interest of food production as well as revenue. There are cases of construction due to inadequate waterways and insufficient number of crossings which have led to construction of unauthorised crossings. These practices lead to deterioration of drainage channels.

Drains

8.5.2. Persual of the States replies reveals that, so far as encroachments into drains are concerned the practice does not have the sanctity of law in any State. This is prohibited by law in Assam, Bihar, Haryana, Punjab, Jammu & Kashmir and West Bengal. Still the practice continues in Assam primarily on account of pressure of population, in Bihar for brick-kiln industry, in Jammu and Kashmir for the State's inability to enforce the enactment due to lack of magisterial powers and enforcing agency with the Flood Control Department and in West Bengal due to reluctance on the part of the Police Department to act effectively coupled with interference at the local political level. Enforcements are practised in Orissa for brick kilns on private land in drainage beds. Jammu & Kashmir has certain amendments in view of the existing Acts including setting up of River Police Organisation. Assam is also contemplating certain measures for enforcing evictions.

We feel that since encroachments into drains (natural or excavated) do not have the sanction of law in any of the States in the country and since there is a general agreement that such encroachments have aggravated flood problems, suitable enactments should be made in the States, where not existing at present, to deal with this human and socio-economic problem in the best possible manner with least additional causative factor to the problem of floods. In this context, the aspect of flood plain zoning has been referred to in Chapter XI.

In the States where existing laws cover this aspect, it is suggested that enforcement agencies should be strengthened suitably to tackle this problem effectively.

The pressure of population has resulted in encroachment on flood plains even the beds of smaller streams have been occupied. Many of the natural drainage channels have been reclaimed for the purpose of cultivation, in spite of the same being declared "notified" and rights and titles have/might also have accrued in certain cases like the abandoned beds of some wandering rivers of North Bihar, Lower Damodar and its offshoot channels, etc.

A large number of depressions locally known as 'Talas', 'Beels', 'Chaurs', etc., in Bihar have also been reclaimed for cultivation. This is the case in Haryana and, perhaps, in some other States as well. Flood waters which used to find their way to these depressions and were being detained for long, now get drained off quickly. This has further aggravated the peak floods in drains and rivers.

River bed cultivation

8.5.3. Cultivation of river beds and berms is permitted by law in the States of Rajasthan, Madhya Pradesh, Gujarat and Maharashtra. In Punjab, this is permitted only on a limited scale in the 'Choes' (hill torrents) of Hoshiarpur district. In the case of Bihar, the practice is allowed by the Revenue Department without consultation with the Irrigation Department. Though not covered by any legislation, river bed cultivation is also in vogue in the states of Haryana, Orissa and Tripura. In Orissa, short-term lease is granted by a Revenue Officer unless objected to by the flood control authorities. River bed cultivation is not permitted in the states of Assam, Andhra Pradesh, Kerala, Tamilnadu, Uttar Pradesh and West Bengal; all the same the tendency persists in Uttar Pradesh. The States of Haryana, Gujarat and Maharashtra are in favour of this practice. According to Haryana, cultivation in the beds and berms of the rivers has no ill effects on the flow and regime of the river; as such the State would like to encourage plantation on the berms as it prevents tendency to erosion. Gujarat has stated that according to model studies by the CWPRS on the river Narmada near a railway bridge, the river bed cultivation has made the bed inerodible and arrested natural scouring. However, its effects on spills over the banks are not so appreciable as to cause concern. Maharashtra permits river bed cultivation for hot weather crops like water-melon which do not cause significant obstruction particularly because the rivers have very little flow in hot weather and the encroachment is negligible. Although not approving of this practice, Bihar has no instance to quote where the flood level has actually increased or the river beds have risen due to silting on account of river bed cultivation. However, the State considers that some sort of legislation seems necessary to regulate such cultivation.

We find that although there is no evidence to show that cultivation of river beds and berms have aggravated the flood situation to any significant extent, we recommend the same should be allowed with a caution that crops like water-melons, vegetables, etc., having relatively shallow roots only are permitted.

Diaras and Khadirs

8.5.4. In Bihar, cultivation in the "Diaras" and "Khadirs" has not caused any significant adverse effect on the river morphology but the same cannot be said in the case of old "Dhars" (abandoned channels) declared as "notified" channels by the State Government (which prohibits any obstruction or use of these abandoned river beds for cultivation or fishing); these activities are carried on with impunity. Persons making use of the "Dhar" bed in a number of cases have even acquired titles by virtue of "adverse possession" i.e. being in physical possession of the land for more than 12 years continuously on the basis of lease granted to them by the erstwhile Zamindars and now the Revenue Officers.

Such cultivation/obstruction retards quick flow of drainage channel, causes heavy siltation at the outfall point in the main river thereby changing its flow and regime condition, aggravates inundation of low-lying areas, raises subsoil water table and breeds unhealthy climate.

We recommend that the practice of cultivation in the abandoned beds of "Dhars" which discharge into main rivers should be stopped strictly by enforcing the existing laws.

Of late, Bihar State has a scheme to renovate these old "Dhars" which also act as trunk drainages, as a part of the drainage scheme to be taken up in a big way. There is provision for land acquisition of the land in the drainage scheme on which titles have accrued to the land owners. "Dhars" on which no such title has accrued but are being cultivated will be considered an act of encroachment, and appropriate legal action taken.

Temporary bunds

8.5.5. Construction of temporary bunds for irrigation and/or fishing is permitted by law in the States of Bihar, West Bengal, Orissa, Manipur, Tripura and Maharashtra. In Haryana, controlled fishing is regulated by certain Acts. In Orissa, Tripura, Jammu & Kashmir and Maharashtra, this is more in the nature of minor irrigation to overcome a drought situation besides encouraging double cropping in Manipur. It is not an unmixed blessing in West Bengal since being under water the bunds cannot be fully removed. In Maharashtra, these earthen bunds are Katcha, very small and get washed away during monsoon. Construction of temporary bunds for irrigation or fishing is not practised in Gujarat and not permitted in Andhra Pradesh, Assam, Punjab, Rajasthan, Madhya Pradesh and Uttar Pradesh. Madhya Pradesh is against this practice whereas West Bengal, Manipur and Tripura are in favour. As a matter of fact, Governments of Manipur and Tripura are themselves actively participating/associated with this practice. Here again, Bihar is of the opinion that some sort of legislation is necessary to regulate this activity as also to remove its ill effects.

Although there are Acts against encroachment/causing blockade in the natural drainage channels by putting bunds/shifting barriers/cultivation, these Acts have seldom been applied or proved useful. It appears, legal and administrative regulations are very difficult to enforce unless public opinion is educated sufficiently about the advantage of these measures.

8.5.6. Unauthorised crossings over drains are not permitted in the States of Assam, Gujarat, Kerala, Uttar Pradesh and West Bengal. These are not practised in the States of Andhra Pradesh, Orissa and Tripura. In case of Gujarat, since no appreciable drainage works have been executed so far, cases of unauthorised crossings have not yet come to notice. The position about existence of unauthorised crossings in Madhya Pradesh and Rajasthan is not clear. While no special measures are adopted to prevent unauthorised crossings over drains in Rajasthan, the prevention of unauthorised crossings over natural drains is a function of the Revenue Department in Madhya Pradesh, but no information or comments have been furnished. Bihar considers the present arrangement as inadequate to prevent unauthorised crossings leading to obstruction or deterioration of drains and has, therefore, suggested that legislation regulating the same with a penal clause for unauthorised crossings is necessary.

We observe that the problem of unauthorised crossings over drains is also significant. We recommend that where suitable legislation regulating the same with a penal clause for unauthorised crossings has not been enacted, the same should be enacted and enforced.

सत्यमेव जयते

ANNEXURE 8.1

List of sections of National Highways and State Highways which experience distress frequently during floods in Bihar

Name of N.H.	Name of Section	Milage affected	Year of flood
1	2	3	4
N.H. 31	Biharsharif Bakhtiarpur Section	85 to 95 miles	
	Bakhtiarpur-Barauni Section .	33 to 51 miles	1976
	Barauni-Khagaria'-Phulwaria-Kishanganj Section	246 to 265 274-279 K.M. 315 to 318 K.M.	
N.H. 30	Patna Bakhtiarpur Section	9 to 16 miles, 19 to 23 miles	
	Bihta Arrah Section .	33, 34 miles	1976
	Arrah-Sasaram Temporary N.H. 30	1 to 8, 17, 19, 22 to 30, 24 to 40	

State Highways

Sl. No.	Name of Roads	Milage affected	Year of flood
1	2	3	4
1.	Chapra Sonepur Road .	8 to 13	1974, 75, 76
2.	Siwan Chapra Road	3 to 6	1975, 76
3.	Chapra Manjhi Darauli Guthani Road	1 to 5	1974, 75, 76
4.	Chapra Salempur Road . .	6	1975, 76
5.	Monghyr Ghat Rasidpur Road	2 to 3	1974, 75, 76
6.	Khagaria Monghyr Ghat Road .	1 to 3	1974, 75, 76
7.	Khagaria to Alauli Road .	3	1974, 75, 76
8.	Motihari Dhaka Belwaghat Road	5 to 8	1975, 76
9.	Motihari Barwaghat-Chauradano Rd.	4, 5	1974, 75, 76
10	Motihari Madhubanghat Road	9	1974, 75, 76
11.	Bettiah-Sewaghat Mainatanar Rd.	7 to 10	1974, 75, 76
12.	Bettiah Champatia Narkatiaganj Road .	1 to 22	1974, 75, 76
13.	Muzaffarpur Sitamarhi Road .	8, 17 to 21, 24	1974, 75, 76
14.	Runisaidpur Katra Kootsa Road .	1 to 5	1974, 75, 76
15.	Sursand Benipatti Road .	0-2	1974, 75, 76
16.	Sitamarhi Bajpatti Puri Road .	8	1974, 75, 76
17.	Sitamarhi Seohar Road .	9 to 13	1974, 75, 76
18.	Muzaffarpur Hajipur Road .	4, 13, 14	1974, 76
19.	Muzaffarpur Deoria Road .	8, 10, 14, 16, 18, 19	1974, 76
20.	Muzaffarpur Mahud Road .	5, 7, 15, 16, 18	1974, 76
21.	Deoria Jaffarpur Ambara Road .	7, 8	1974, 76
22.	Motipur Sahibganj Road .	3 to 7, 11	1974, 76
23.	Bihpur Birpur Road .	65, 73, 75, 79	1974, 75, 76
24.	Bihpur Birpur Road from 80th mile to Bhimnagar .	1, 3, 4, 5,	1974, 76
25.	Mirganj-Jadia Balua Road .	1 to 16	1974, 75, 76
26.	Maheshkunt Pansalwa Sonbarsa Road	1, 2, 4 to 7	1974, 75, 76
27.	Supaul Pipra Road . . .	2, 4, 6, 11 & 12	1974, 76
28.	Araria Kursakata Road .	3 to 5, 8, 15, 16, 17	1974, 75, 76
29.	Purnea Forbesganj Road .	43, 46	1974, 76
30.	Purnea Murliganj Road .	13 to 15	1974, 76
31.	Purnea Dhamdaha Rupali Road .	7, 17	1974, 76
32.	Araria Jokhihat Palasi Road .	11, 16, 17, 18	1974, 76

सत्यमेव जयते

1	2	3	4
33.	Kisanganj Taibapur Thakurganj Galgalia Road .	8, 20, 27, 28	1974, 76
34.	Jogbani Kalabalua Road	3, 12, 13 & 28	1974, 76
35.	Sarsi Kursela Road .	1, 4, 6	1974, 76
36.	Katihar Manihari Road .	4, 5, 6, 7	1974, 76
37.	Darbhanga Samastipur Road .	1, 4, 11	1974, 76
38.	Darbhanga Kamtaul Basaitha-Madhupur Road .	1 to 9	1974, 75, 76
39.	Bahri Singhiya to Rosra Road	11	1974, 75, 76
40.	Jale Atarbell Road .	2 to 15	1974, 75, 76
41.	Bahera Birol Kurseshwarasthan Rd.	1, 3, 6, to 12 16, 18, to 23	1974, 75, 76
42.	Jainagar Ladania Road .	2, 3, 5, 6	1974, 75, 76
43.	Madhubani Rajnagar Babubarhi Khutauna Road .	3, 4, 5, 9	1974, 75, 76
44.	Khajauli Basopatti Harlakhi Road	5	1974, 75, 76
45.	Padma Chapk Ladaniya Laukaha Laukahi Phulparas Road .	9, 13, 14, 15, 16, 17,	1974,75, 76
46.	Monghyr Bariarpur Road	92, 108, 117, 118, 120	1975, 76
47.	Lakhisarai Sheikhpura	10	1975, 76
48.	Bhagalpur Colgong Sahebgabh Road.	37	1974, 75, 76
49.	Sahabganj Rajmahal Udhwanala Barharwa Road with link to Talghari.	12, 13, 14, 16, 17	1975, 76
50.	Bihta Bikram Pai Arwal Road	3, 10, 14, 24	1974, 75, 76
51.	Mokameh Barahiya Road	61, 62, & 56	1975, 76
52.	Sadiquepur Pavera Masurhi Road		
53.	Bettiah Sugauli Section of Bettiah Motihari Road		
54.	Mahbar Mohiuddinnagar Bachwara Road		
55.	Aurangabad Daudnagar Road		
56.	Sheoganj Rafiganj Goh Upahara Road		
57.	Arwal Jehanbad Road		
58.	Monghyr Gharghat Road		
59.	C 'gong Sahebganj Road		
60.	Chagari Monghyrghat Road		
61.	Monghyrghat Rasidpur Road		

NOTE. —The lists are as submitted by the Bihar State.

ANNEXURE 8.2

List of sections of National Highways and Railway Crossings which experience distress frequently during floods in Rajasthan

National Highways

(i) National Highway in the upstream of Jal Mahal near Jaipur (Mansagar).

(ii) National Highway from Jaipur to Ajmer near Hingonia tank.

(iii) National Highway from Jaipur to Agra between Mahwa and Bharatpur

Railway Crossings

(i) Agra-Bayana Section of Western Railway near Railway Station. Singhawali due to silting up of the Singhawali Railway bridge.

(ii) Sabi River bridge on Bandikui-Rewari Section of Western Railway (M.G. Section).

(iii) Northern Railway-Phulera-Merta Road Section Sambhar Lake and Newa Town.

(iv) Suratgarh-Sarupsar-Anupgarh Section of N. Rly, due to submergence of Rly. track from flood waters of Ghaggar River.

NOTE: The lists are as submitted by the Rajasthan State.

ANNEXURE 8.3

List of sections of National Highways and State Highways which experience distress frequently during floods in Uttar Pradesh

(a) *National Highways*

1. National Highway No. 11—Agra, Bhaun, Jaipur Road, Km. 18 & Km. 36 to 43.
2. National Highway No. 2—G.T. Road, Saisus Khaderi Bridge at Allahabad.
3. National Highway No. 29—Varanasi-Gorakhpur Road (3 maps enclosed).

(b) *State Highways*

1. Lumbini Dundhi State Highway No. 5 in Basti District, Km. 44 to 56.
2. Melidawal-Karmaini Ghat Road in Basti District, Km. 2, 3, 6 and 7.
3. Dhebarua-Soharatggarli Road in Basti District, Km. 1, 2 and 3.
4. Babarpur-Phaphundhwad in District Etawah, Km. 10.
5. Mohamadabad-Shamshabadwad in District Farrukhabad, Km. 16.
6. Lucknow-Varanasi S.H. No. 36 in Jaunpur District, Km. 246 and 271.
7. Buxar Phephana Road in Ballia District, Km. 17 & 25.
8. Kaptanganj-Tahabupur Road in Azamgarh District, Km. 3 and 4.
9. Azamgarh-Faizabad State Highway No. 30, Km. 220, 222, 229, 230, 234, 253 and 254.
10. Azamgarh-Dohrighat Road in Azamgarh District, Km. 8, 9, 12, 13, 14 and 15.
11. Varanasi-Azamgarh Road in Azamgarh District, Km. 44, 45, 46, 48 and 71.
12. Budhanpur-Deedarganj Road in Azamgarh District, Km. 29, 30 and 31.
13. Cheraiyakot-Mehrajpur Road in Azamgarh District, Km. 6, 10 and 27.
14. Kaptanganj-Ora-Gaura Road in Azamgarh District, Km. 3, 4, 5 and 6.
15. S.H. No. 43, S.H. No. 29 and B.E. Road in District Farukhabad.
16. Bilaspur-Milak Khanam Road in Rampur District, Km. 4.
17. Bijnor-Nangal-Najibabad Road in Bijnor District, Km. 114.
18. Bhanera-Memon-Sadar Road in Bijnor District, Km. 2.
19. Moradabad-Farrukhabad Road (S.H. No. 43 in Shahjahanpur District, Km. 142, 155 and 158).
20. Bilgram Saadi Allahganj Road in Shahjahanpur District, Km. 56 and 58.
21. Pallia Shahjahanpur Hardoi Lucknow Road (S.H. 25) Km. 56 and 58.
22. Gola Bilasanda Road in Shahjahanpur District, Km. 30, 36 and 42.
23. Jalabad Khandhar Road in Shahjahanpur District, Km. 7 and 8.
24. Katra Khudagung Road in Shahjahanpur District, Km. 12, 14 and 16.
25. Gola Shahjahanpur Road in Shahjahanpur District, Km. 51 and 52.
26. Pawayanpur Anpir Road in Shahjahanpur District, Km. 11.
27. Jalabad Dhaighat Road in Shahjahanpur District, Km. 8 and 11.
28. Kalan Parnar Road in Shahjahanpur District, Km. 1, 2 and 5.
29. Nawabganj-Bijoria Road in Bareilly District, Km. 3.
30. Bareilly-Mathura Road in Bareilly Disrict, Km. 68.500 to 69.000.
31. Balia-Shishgarh Road in Bareilly District, Km. 9.700 to 10.000.
32. Pilibhit-Madhotanda Road in Pilibhit District, Km. 21 and 25.
33. Deoriakalan-Puranpur Road in Pilibhit District, Km. 9, 10 and 13.

सत्यमेव जयते

Note: The lists are as submitted by the Uttar Pradesh State.

ANNEXURE 8.4

Extracts from Clauses 103 *and* 104 *of Section I of the Code of Practice for road bridges* (*IRC Standard*: 5—1970)

"103. *Determination of Design Discharge*:—

103.1. The design discharge for which the waterway of the bridge is to be designed, shall be the maximum flood discharge on record for a period of not less than 50 years. In case where he requisite information is not available, the design discharge shall be maximum estimated discharge determined by consideration of the following or any other rational method.

103.1.1. From the records available, if any, of discharge observed on the stream at the site of the bridge or at any other site in its vicinity.

103.1.2. From the rainfall and other characteristics of the catchments:

(i) by use of an empirical formula, applicable to that region, or;

(ii) by a recognised method, provided it is possible to evaluate for the region concerned by the various factors employed in that method.

103.1.3. By the area velocity method with the help of hydraulic characteristics of the channel.

103.1.4. By unit hydrograph method.

103.2. Where possible, more than one method shall be adopted, results compared and the maxinum discharge fixed by judgment by the engineer responsible for the design. The bridge shall be designed for this maximum discharge.

103.3. Freak flood discharges of high intensity-exceptional discharges of high intensity due to he failure of a dam or tank constructed above he bridge need not be catered for and the maxinum estimated discharge from the catchment area should be considered for design of the bridge."

No particular empirical formula for estimating discharge has been specified. The practice adoped for road bridges as stated in the explanatory notes published in Volume X of the I.R.C. Journal 1946 is reproduced below:

"Various empirical formulae for estimating the maximum discharge from a catchment have been presented from time to time. Typical among these which are in common use nn in India are:

(a) Dicken's formula :
$Q=CA^{\frac{3}{4}}$ (Orginally devised for conditions in Northern India).

(b) Ryve's formula
$Q=CA^{\frac{2}{3}}$ (Originally devised for the Madras Presidency).

(c) Inglis formula
$Q=\frac{7000 \cdot A}{A+4}$ (Orginally devised for the Bombay Presidency).

Where Q=the maximum flood discharge in cusecs;

A=the area of catchment in sq. miles; and

C=an empirical constant, which

for Dicken's formula
=825 for conditions in Northern India
=1600 (according to Beale) for Western Ghats and
=1000—1400 for conditions in Central Provinces, and

for Ryve's formula
=450 for areas within 15 miles of the coast;
=563 for areas between 15 and 100 miles from the coast; and
=672 for limited areas near the hills.

The values of these coefficients can be further modified when applying these formulae to localities, other than those for which the formulae were originally devised."

"104. *Determination of Linear Waterway and Effective Linear Waterway.*

104.1. For artificial channels (irrigation, navigation and drainage), the effective linear waterway shall generally be such as to pass the full discharge at normal velocity but concurrence shall invariably be obtained from the authority controlling the channel. If it is proposed to flume the channel at the site of the bridge, this fluming shall be subject to the consent of the same authority and in accordance with the essential requirements.

104.2. For non-meandering channels in alluvial beds but with well-defined banks and for all natural channels in beds with rigid inerodible boundaries, the linear waterway shall be the distance between banks at that water surface elevation, at which the designed maximum discharge determined in accordance with Clause 103 can be passed without creating harmful afflux.

104.3. For natural channels in alluvial beds and having undefined banks, the effective linear waterway shall be determined from the design discharge, using some accepted rational formula at the discretion of the engineer responsible for the design. One such formula for regime conditions is:

$$W = C\sqrt{Q}$$

Where W=the effective linear waterway in meters;

Q=the design maximum discharge in m^3/sec;

C= a constant usually taken as 4·8 for regime channels but it may vary from 4·5 to 6·3 according to local conditions.

104.4. If the river is of a flashy nature and th bed does not submit readily to the scourin effects of the flood, the waterway should be determined by the area velocity method takin into account the design flood level and the characteristics of the bed material as well as wate surface.

104.5. Where it is decided to adopt measure which are likely to affect the volume of the tida flow and other characteristics of the tide, i shall be ensured that no port or harbour or othe installations in the proximity of the bridge ar adversely affected.

104.6. For calculating the effective linea waterways (as defined in Clause 101.8) the widt of obstruction due to each pier shall be taken a the mean submerged width of the pier and it foundation up to the maximum scour level. Th obstruction at the ends due to the abutments o pitched slopes shall be ignored."

सत्यमेव जयते

XI—METHODOLOGY OF FLOOD DAMAGE ASSESSMENT

9.1. Importance of scientific assessment of flood damage

Data on damages caused by floods are needed for several reasons. Traditionally, the most important use has been for determining the extent of suspension/remission of land revenue and quantum of gratuitous and other relief to people affected by floods. A more important use of these data, particularly, from our point of view, is for assessing benefits from flood control projects as part of benefit-cost analysis at the pre-sanction stage. The overall significance of this consideration has increased considerably as a result of the steadily rising outlay on flood control/protection. These data also give an idea of the havoc caused by floods and enable the legislators and the public to form an informed opinion about the extent of the flood problem affecting various parts of the country at any point of time. There is, however, general agreement that the quality of flood damage data needs considerable improvement.

9.2. Present status of flood damage data

9.2.1. *Data content*

The then Central Water and Power Commission which was responsible for compilation and consolidation of flood damage data at the national level had initiated steps for assessment of such damages at the State level as early as in 1955. The guidelines issued by it in June 1955 provided a framework for collection of detailed data on areas affected by floods and losses to crops, residential property including personal effects and public institutions. Crop losses called for information on (i) depth, duration and area of flooding, and (ii) yield of (a) partially damaged crops, (b) replanted crops and (c) alternate crops compared to normal/average yields along with additional costs of cultivation consequent to floods. Damage to residential property and personal effects called for information on type of property, plinth area, value of damage as measured by cost of repairs, loss of rent, cost of temporary quarters and other overheads. Collection of data on damage to public instiutions required information on the nautre of the institution, value of damage, number of working days lost, salary and arrears paid during closed period, cost of clearance and other costs.

9.2.2. Keeping in view the minimum data required in connection with formulation of flood control projects, a simpler *pro forma* was circulaed by the then Ministry of Irrigation & Power, in October 1955. It elicited information on area flooded, frequency of floods, probable depth nad duration of inundation, crop area damaged, and value of damaged crops, number and value of houses damaged, number of human lives lost, number and value of cattle lost and damage to public utilities apart from certain details of agricultural loans and relief measures. Flood damage statistics, on the basis of this *proforma* are, by and large, being collected in the States and reported to the Centre.

9.2.3. *Data agencies*

Revenue Departments of the State Governments are generally responsible for coordination and publication of flood damage statistics at the State level. The only exception in this regard is Andhra Pradesh where the Irrigation Department looks after this work.

9.2.4. Work of collection of data is divided among different departments of the State Government. Information regarding area affected and losses suffered by the public on account of damage to crops and houses, and death of cattle is collected through the District Magistrate/Collector who is assisted by Revenue Officers working under him. At the lower level the Sub-Divisional Officer, the Tehsildars or Block Development Officer and other sub-ordinate staff are involved in this work. Data on damages to public property such as roads, buildings, canals, embankments, tubewells, hospitals, etc., are collected by the departments responsible for construction and maintenance of such property. Similar information relating to the Central Government properties such as Railways and Posts and Telegraphs is collected by the concerned Divisions or Circles of the respective Central Government Departments. However, since the returns are not sent in time to the Revenue Department, this part of the information is generally missing from the damage data reported.

9.2.5. With respect to collection of information at the village level, the practices followed in States differ. In some States as in Uttar Pradesh, Punjab and Haryana, the work is done by lekhpals or patwaris who are the village level functionaries of the Revenue Department. In some other States like Bihar and West Bengal, it is taken care of by gram sewaks or village level workers who are the functionaries of the Develoment Department. Information collected at the village level relates mainly to the total area and the croped area affected by floods and the extent of crop damage. The estimate is made on the basis of visual assessment by village level functionaries. It is generally at the block level that physical damages are converted into monetary losses, using data relating to the average yields of crops and their current market prices. It is at this level that the standard proformae prescribed by the Centre are generally used for transmitting data to higher authorities. The assessment of damages is made during the floods or immediately thereafter.

9.2.6. The damage figures reported by village officials are supposed to be checked by supervisory staff but more often this is not done. With respect to damage to houses, however, there is provision in several States for scrutiny because such damages generally qualify for relief by Government. For example, in Bihar there is a provision that the Circle Officer should varify 10 per cent of the cases reported by the panchayat sewak and the Block Development Officer should verify 2 to 3 per cent of the cases. No such verification is usually done in respect of damage data relating to crops.

9.3. Views of past committees

9.3.1 The importance of flood damage data has been recognised by all those who have been associated with formulation and appraisal of flood control projects and suggestions for improvement made.

9.3.2 The High Level Committee on Floods (1957) stressed the need for improving the techniques of assessment and reporting. It suggested that information relating to damage to public properties such as roads, canals etc. should be sent by concerned State Departments to their counter-part Ministries at the Centre with copies to Flood Control Department of the States. At the Centre, all flood damage information was to be made available to the then Central Water and Power Commission by various Ministries.

9.3.3 The Sub-Committee of the River Commissions (1959) made a suggestion for collecting more detailed information. They prescribed eight *proformae* seeking information on various aspects like area affected, rivers and tributaries causing flood, flood frequency, depth of inundation, duration, damage etc. Under each category direct and indirect damages were to be recorded and assessed in monetary terms. It was envisaged that the Flood Control Department would coordinate the work of data collection at the State level. The eight *pro formae* mentioned above were to be filled in by local officers of the Irrigation and Flood Control Department, Highways Department, Railways, Posts and Telegraphs. Electricity, the Municipality and the Collectorate. These officers were to endorse copies to the Flood Control Department which was to compile basin-wise and district-wise data for the whole State and forward it to the then Central Water and Power Commission, which in turn, was to compile the data for the whole country, basin-wise and State-wise. These recommendations were supposed to have been put into effect from 1960. Though the *pro formae* were approved by the Central Flood Control Board after some modifications in 1964, no action was taken by the States to enforce them except in Andhra Pradesh. After having administered the scheme for some years, the Chief Engineer of Andhra Pradesh reported that the process of obtaining reports from so many officers was taking a lot of time in view of the cooperation required from various departments and suggested that the Collector, being the head of District administration, would be in a better position to get the requisite data collected. This suggestion was not, however, accepted by the State Government.

9.3.4. The Minister's Committee on Flood Control (1964) noted the unsatisfactory state of flood damage assessment and underlined the need for improving the then prevailing techniques of field collection, assessment, recording and reporting of damage data. They recommended that Flood Control Department should send out field teams at the end of every flood season to contact the other agencies collecting the relevant data, visit flood affected areas to ascertain the damages from local population and make their own assessment. In this work, that Department was to engage field assistants in the same manner as enumerators are engaged by the Census Department at the time of census. The Committee also recommended that collection of any specific information required by the Flood Control Department but not so far collected, should be its own responsibility.

9.3.5. The National Council of Applied Economic Research (NCAER) which examined the subject in greater detail gave more or less similar recommendations in regard to the agency for coordination of information at the State level. While non-agricultural damage data would continue to be collected by the concerned departments, the primary responsibility for the assessment of agricultural damages was assigned to the Flood Control Department for which purpose a separate Statistical Unit was suggested. Estimation of agricultural damage was to be done by the Flood Control Department through sample surveys, the execution of which at the lowest level would have been the responsibility of village karamcharis working under the direct supervision and guidance of the Assistant Engineer of the Flood Control Department or his subordinate staff.

9.3.6. The Minister's Committee on Floods and Flood Relief (1972) endorsed the recommendations made by the NCAER and urged that those should be implemented by all States without delay. In the matter of collection of statistics, particularly with regard to loss of human lives, the Committee cautioned that care should be taken to ensure that only losses due to flood were included. Losses due to other reasons such as land slides, heavy rain-fall, boat capsize etc. should not be treated as loss due to floods.

9.3.7 Thus the various Committees mentioned above have either directly or indirectly referred to the unsatisfactory state of flood damage statistics and emphasised the importance of scientific assesment. They made several suggestions for improving the system of collection, processing and reporting. However, despite all efforts made from time to time, not much improvement has taken place.

9.4. Methology for data collection

9.4.1 There are two standard methods of collecting data: through complete enumeration, and through sample surveys. The existing procedure is based on complete enumeration. A methodology based on sample surveys has been recommended by the NCAER.

9.4.2 The NCAER proposal envisages that the States would be divided into zones on the basis of their exposure to flood risks and villages would for purposes of study be randomly selected from different strata. Each flood zone would form part of a river basin or sub-basin and might comprise a few districts/parts of districts. Difficulties could arise in respect of some areas affected by more than one river. In uch cases, some convention based on past experience like grouping the area into any one of the zones, was to be established. Once the job of demarcation of flood zones had been completed, the set-up was not changeable. Within each district or part of a district, a sample of villages was to be selected well in advance of the occurrence of flood according to the proportion of area flooded in previous year. The number of villages selected were to be large enough to provide an accurate estimate of crop damages. The selection of zones, villages etc. was to be done by the statistical unit to be established at the headquarters of the Flood Control Department. The field work relating to the survey in the selected villages was to consist of (a) pre-flood enquiry (b) inter-flood enquiry and (c) post-flood enquiry. However, only post-flood enquiry was to be conducted in areas where flood risk was not generally anticipated. Pre and post-flood enquiries required plot to plot enumeration. In areas subject to multiple flooding the same sample villages were to be surveyed after every flood and damage figures aggregated to obtain total damage for the village. The damage data of selected villages were to be used to make an estimate of crop damages for the district or part of the district in which the selected villages were situated. The district estimates in physical terms could then be broken down into block level estimates in proportion of the flooded area in blocks within the district.

9.4.3 The sampling technique can be applied only under expert statistical guidance which, at present, is not available in the Flood Control Departments in most of the States. Hence the implementation of the recommendation would require recruitment of additional staff. However a more fundamental point is that the method of sample survey is resorted to only when the census method *i.e.* complete enumeration is not considered feasible on account of considerations involving funds, personnel etc. In the case of flood damage assessment, a system based on complete enumeration is already in existence in most of the States. It is not likely that a sample survey undertaken by the same revenue staff would yield results better than those obtained from complete enumeration. Moreover, the method of sampling is not very useful where information is required not only at the district or higher levels but also at lower levels of blocks and villages for purposes of relief administration. And the method being time consuming, information cannot be provided quickly for use by authorities at the tehsil or district levels. The realisation of this limitation led the NCAER to suggest preparation of quick estimates of damages similar to what is being done at present. The sample survey work was thus to become something in addition to what is already being done. This could be done only if the Revenue Department could spare enough karamcharis for this work during the flood season, which does not appear to be a practical proposition. We, therefore, recommend that the present methodolagy based on complete enumeration be retained and improved upon.

9.5. Procedures for estimates of crop damages

9.5.1 In spite of their declining share, damages to crops constitute more than 60 per cent of the total flood damages in the country and hence greater care is needed in their assessment. The present method, however, has a built-in bias towards over-estimation on account of several reasons, the most important being the practice of estimating damages in terms of loss of potential output. This procedure would be apt if no replanting or resowing takes place. However, from our analysis of past data on flood damages, inspection of field conditions subsequent to floods, as well as discussion with knowledgeable people, we get a feeling that replanting/resowing of the same or another crop is quite common specially when floods come early in the season. In such cases, a more correct assessment of the crop damage should be provided in terms of the infructuous expenditure incurred on inputs including labour charges, seeds and loss of yield. It is likely that the preliminary estimates prepared quickly for the purpose of relief administration may not take into account the extent of replanting/resowing which will be known only after some time. But, the final estimate of damage should take such areas into account. This, however, would require information on crop areas completely destroyed and areas replanted/resown and some norms of input loss in case of areas completely destroyed. The extent of input loss would no doubt vary with the stage of the crop at the time of floods. For the sake of convenience, this information can be given in terms of two distinct crop stages (a) tillering phase covering sowing of seeds, germination and early phase of plant growth upto tillering and (b) the pre-flowering phase to cover plant growth from the stage of tillering to just before flowering. Damage after flowering is likely to be total without much possibility of replanting or resowing. Norms for the estimate of input loss per hectare in respect of both crop stages for important Kharif crops like paddy, maize, jowar and jute should be evolved by the Agriculture/Statiscics Department.

9.5.2. We, therefore, recommend that the final estimate of crop damage on areas completely destroyed but where replanting/resowing takes place, should be made in terms of loss of inputs. For this purpose, information on (i) stage of the crop at the time of flood in terms of tillering and pre-flowering stages and (ii) crop area completely destroyed but replanted/resown would be required. We would suggest a few marginal changes in the proforma in use for reporting the additional information. An independent column needs to be provided for recording the stage of crop growth at the time of flooding. Under the total crop area inundated, three additional columns may be provided in order to record (i) crop area completely damaged; (ii) area resown/replanted out of item (i); and (iii) area partially affected which is the difference between total cropped area affected and item (i).

9.5.3 As regards the effect of flood on yield of partially affected crop or on replanted/resown crops, it should be assessed by the difference between the normally expected yield and the actually obtained yield as indicated by crop cutting experiments. Three more columns may be added to record crop yields *viz.,* (i) normally expected yield (which is the average of crop-cutting experiments for the preceding five years), (ii) yield of partially affected crop and (iii) yield of replanted crop. It will be possible to obtain the total value of crop damages from the above details. Proformae recommended for use at the village and block levels and above may be seen at Annexure 9.1 and 9.2.

9.5.4 We are aware of some other factors which lead to overestimation of damages. For example, in some cases farmers start rabi cultivation earlier, and owing to silt deposition and residual moisture content after the floods obtain additional yields in comparison to normal years. Similarly, crop yields from fields located on high lands may increase. It quite often happens in diara areas that grown-up maize crop when submerged due to floods is cut and used as fodder for cattle but no allowance is made for the element of partial recovery while estimating damages. On the other hand, excess of moisture due to non-evacuation of flood water in time may delay rabi sowing and consequent loss in production. These factors may, however, be ignored because the procedures for taking them into account will be too complicated to be of much use. The matter may be a subject of research for future consideration.

9.5.5 In order to estimate crop losses in terms of money, figures of crop area, supposed to be completely destroyed, are multiplied by those of crop yields per hactare and prices. It, however, appears that not much care is usually exercised in the matter of choice of the last two variables. Local officers make their own judgement, resulting in diversity of practices. For example, in the case of yields, some use crop-cutting experiment results, some the yield rates given in settlement reports and some an average rate subjectively estimated by the revenue staff. More diversity prevails in the case of prices where procurement prices, farm harvest prices, wholesale mandi prices or some other prices are used. Our considered view in the matter is that in the case of yields, the district yield rates based on crop-cutting experiments should be used as far as possible. During the past few years, the number of these experiments has been increased and now there is hardly a block in the country where such experimental cuts are not conducted. Even then there is need to review the sampling design adopted for crop-cutting surveys for having an adequate number of crop-cutting experiments in flood prone areas and for adopting startification according to crop area partially damaged, area resown and area replanted. With respect to prices, it is suggested that wholesale prices in local mandis during the peak harvesting period, *i.e.* the farm harvest prices, should be the choice. The justification is that farmers would have obtained this price if their produce were not lost due to floods. Since the final assessment is made after the harvesting season, such prices will be readily available.

Integrating area and crop damage statistics with agricultural statistics

9.5.6 Keeping in view the statistical requirements in connection with formulation of flood control projects, the final assessment of damage is very important. The revenue authorities, however do not have much interest in final assessment which can be made not during the time of flood but after some time when crops are harvested. Generally speaking, the reporting comes to an end with the passing of the flood season and no effort is made thereafter to scrutinise the information collected and finalise the return. There is hardly any time schedule prescribed for the issue of final assessment. Quite often the estimates made at the time of flood are maintained as preliminary estimates for sometime and then treated as final without any change in content.

9.5.7. For this purpose, it would be advantageous to draw upon the basic village agricultural statistics in most of the States. According to the requirements of agricultural statistics maintained at the village level, the Patwari or the village level functionary is, after personal inspection, expected to record seasonwise, the area sown to different crops in every field under his jurisdiction. The field-to-field inspection is expected to be completed much before the crop is harvested. As such a complete record of area sown to crops is available seasonwise. What is, however, lacking is the information relating to the extent of crop area affected by floods. A purposeful revision of the basic village form in use in flood prone States can help collection of reliable flood damage statistics particularly about village area and crop area affected and crop losses. New items of information required to be recorded in that case would be the extent of area under particular crops affected by floods along with crop-stage, crop area completely destroyed due to floods and areas resown/replanted in the same season. This additional information, if recorded in the basic village form, should provide an independent estimate of flood incidence and flood damage and could also provide a check on the preliminary estimates made at the time of floods.

9.5.8. In States like West Bengal, where data relating to crop areas are collected through sample surveys, it is even more easy to incorporate the relevant items in the schedule and collect the necessary information which can provide the basis for final reports on flood damages.

9.5.9. Assessment of damage is a specialised job and should be done under expert supervision of persons having professional qualification and competence. The integration of the system of collection of crop damage statistics with that of agricultural statistics will, *ipso facto*, ensure that the former data are also collected under the supervision and guidance of officers of the Statistics Department of State Governments. In this way, advantage can also be taken of efforts being made through the Timely Reporting Scheme introduced in 1969-70 for expeditious completion of village registers by primary reporting agency more systematically and under intensive supervision. Every year one-fifth of the villages under each Patwari circle in the country would be taken up for special enumeration and checking under the scheme thereby covering the entire country in five years.

9.5.10. In addition, this integration will also help facilitate sample verification of flood damage statistics for which there is a strong case. The estimate of crop losses is done on the basis of visual assessment of field conditions of crops during floods by village level officials like karamchari/patwari/gram sewak. Being subjective, the reliability of such estimates remains questionable. It is true that the estimates are supposed to be checked on a sample basis by higher officials. But our enquiry in several States indicated that, in practice, very little checking is done on account of pressure of work. A scheme for sample verification of crop estimates known as Scheme for Improvement of Crop Statistics has been introduced recently for ensuring reliability of agricultural statistics collected in the country as also for greater supervision of the work done in this connection. Every year ten thousand villages are selected from among villages covered under the Timely Reporting Scheme for intensive checking of data collection and supervision. Work in half the number of villages will be supervised by the National Sample Survey Organisation and in the other half by the supervisory staff provided by State Governments for the purpose. At the village level, supervisory staff undertakes sample check of entries made in the village khasra by verifying entries made in respect of 20 survey numbers. In addition, page totals and totals of area under different land use classes and crops in the village khasra are also checked. The supervisory agency also exercises sample check of crop-cutting experiments in selected villages. Thus the scheme provides the necessary guidance, as also an element of compulsion for more accurate work on the part of the primary reporter. It helps to ensure reliability of primary reporting. If details of flood damages in the various fields are recorded in the basic village forms as suggested earlier, their verification on a sample basis is also ensured under this scheme.

9.5.11. In view of its greater importance, agricultural statistics is expected to receive greater attention from authorities. Hence the integration of crop damage statistics with agricultural statistics is expected to bestow upon the former all the advantages of the latter. We are accordingly convinced that the recommendation made here in favour of integration is the most economical and effective way of obtaining more reliable information on final figures of crop damages.

9.6. Use of contour maps and remote sensing technique

9.6.1. Contour maps of a few river basins are available and more are likely to be prepared in the future. These, along with data on river gauges may be used by the Flood Control Departments to derive an estimate of the flooded area. This will provide quick check of area estimates provided by the revenue agencies and may therefore be used on a sample basis to start with and extended to cover the entire flood prone basin as and when contour maps are made.

9.6.2. Another way of exercising a sample check on the extent of the area and the cropped area affected by floods is through remote sensing techniques operated through artificial satellites. The satellite passes over the same ground area every 18 days and the area can be monitored for changes over a period of time. This method seems to have some potential for providing reliable information on extent of area and cropped area affected. Hence it is worthwhile exploring the use of this method in some sample areas to provide a check on the data collected by the revenue staff.

9.6.3. The results of these sample checks should be sent by the Flood Control Department to the agency collecting and compiling figures on area affected for reconciliation. This will greatly enhance the quality of data collection.

9.7. Damages to private property and loss of lives, cattle, etc.

9.7.1. Besides crop damages, the revenue agency also collects data on the number of people affected, damage to houses, loss of cattle and loss of human lives. From our analysis of past data on damages as well as from enquiries in several States we find that the procedures followed in collecting figures relating to house damages are more systematic, presumably because damaged houses owned by specified categories of households qualify for house-repair grants from Government according to prescribed norms. Hence, these figures are checked and verified by senior officers. Some further improvement can be brought about by including household goods damaged during floods, but we do not recommend this at the present stage on account of the difficult problems of estimation which will be encountered. Meanwhile necessary steps such as aiding and sponsoring research and setting up enconomic cells for conducting suitably designed economic surveys in order to prepare the ground for eventual collection of data on damages to household goods on a regular basis should be taken by the State Governments. In regard to loss of cattle, the monetary value of such losses should be estimated. With respect to loss of life, it is observed that what is reported as deaths due to floods include a number of accidental deaths resulting from capsizing of boats, house collapse due to excessive rains, etc. It is suggested that loss of lives due to floods only should be taken into account.

9.8. Damages to public property

9.8.1. While the question of bringing about improvement in the collection and compilation of data relating to crop damages has attracted a goo deal of attention in the past, little or no importance has been given to non-agricultural damage particularly damages to State Government property such as buildings, public utilities, road canals, embankments and the like. The analysi made in Chapter IV indicated that the proportio of damages to government properties to tot damages has been increasing and, at present stands at about 25 per cent of the total damage If this trend continues, these damages, in cours of time, may equal or even exceed agricultra damages. If is, therefore, necessary that suc damages are also estimated as accurately a possible.

9.8.2. According to the existing procedure thes damages are assessed by the respective Departments on the basis of estimated cost of repairs But because of paucity of funds, such repairs ar not necessarily carried out in the same year. A a result, the method of assessment followed leave scope for double and multiple counting of th same damage particularly in areas subject t frequent flooding. For instance, damages to structure in a particular year may not be repaired before the onset of the next rainy season o account of paucity of funds and are likely to b included in the estimate of damages for the ensuing years also. We recommend that adequate steps should be taken to obviate such doubl counting. Sample checking and verification, bein an integral part of any scientific methodology o data collection, should be introduced.

9.8.3. The reporting of data relating to publi property is generally incomplete. On-the-spot enquiries at the district level in Uttar Prades showed that most departments furnished onl rough estimates with no details. These enquirie indicated that details of damages and demand fo repairs are prepared by the field staff and submitted to departmental heads for approval, but these are not communicated to the concerned department which collects flood damage data at the district level. It is, therefore, recommended that the final estimate of damages prepared by the various departments should be communicated to the coordinating agency at the district level for including them in district figures.

9.8.4. The figures compiled by State Governments do not include damages to properties of the Central Government such as railways, posts and telegraphs, defence installations, major industries, etc. Hence they are not included in the estimate of total damages for the country as a whole prepared by the Central Water Commission. It is, however, understood that damages suffered by the Central Government undertakings are assessed by local or zonal officers of respective departments on the basis of estimated cost of repairs. Such estimates of damages should also be taken into account while preparing consolidated figures of damages at State and national levels.

9.9. Indirect damages

9.9.1. The flood losses considered so far belong to the category of direct damages defined as damages arising out of direct contact with flood waters. However, damages may also be caused by cessation of normal economic activities on account of floods, even though persons or assets affected may not come in direct contact with it. For example, factories, shops and business houses in flood affected areas may be closed, resulting in loss to their owners, stoppage of industrial production and temporary unemployment of workers. Rail and road communication in affected sections may be interrupted resulting in reduced earnings for railways and transport operators. Daily wage earners and small pedlars, etc., working in the affected area may suffer loss of their daily wages/earnings. Such losses may occur not only in the areas flooded but also outside due to presence of forward and backward linkages. For example, a factory located elsewhere but depending on raw materials from the flooded area may suffer loss on account of cessation of supplies. Similarly, firms selling their output to flood affected areas may suffer losses. These examples are only illustrative and not exhaustive.

9.9.2. However, measurement of indirect damages poses intricate problems. Firstly the net quantum of such losses suffered by factories, shops, business houses, etc., should be determined only after deducting the savings made by them in not buying inputs during the period of closure. This would require involved calculations. Secondly, the losses made during floods may sometimes be recouped at least partially if not wholly after floods have receded: people who might have postponed their journeys during flood season would undertake the same, and those who did not sell their output may sell more to satisfy the pent-up demand. These need to be adjusted. Thirdly, in view of the endless chain in forward and backward linkages, one does not know where to stop. Fourthly, it is also known that at some point fairly early in the production chain, there will be substitution by alternative supplies, thereby terminating the possibilities of loss. Such losses are likely to be more important in an industrial economy such as the U.S.A's. rather than in an agricultural economy like India's. The NCAER which had conducted a survey of such damages in north Bihar villages affected by floods in 1965 found that they were not quantitatively significant. Even in urban and industrial centres, damages caused by exceptionally heavy floods only are likely to be significant. For example, railway lines which are laid usually at higher elevation would be affected only by very heavy floods. In view of the considerations mentioned above, it is not considered advisable to include indirect losses for the time being. However, the Flood Control Departments at the Centre and in the States should arrange for exploratory studies and sample surveys to be conducted for throwing more light on their significance and for indicating norms for including them in future.

9.10. Additional classification of data required

9.10.1. While processing and tabulating data, classifications considered desirable may be introduced depending upon the requirements of concerned departments of the Government. Very often, figures of damage in protected areas are needed to determine the efficacy of flood control measures adopted in the past. It is also necessary to have the information separately for non-protected areas and areas situated within two embankments on either side of rivers. We, therefore, suggest that flood damage statistics may be reported separately for the following three categories of areas:—

(i) unprotected areas;

(ii) protected areas; and

(iii) areas situated between the embankments and the river.

Information about the boundaries of these areas in terms of blocks and villages should be supplied by Flood Control Department.

9.10.2. Areas affected by drainage congestion in flood prone districts very often pass as flood affected as no distinction is made between various causes of inundation, like drainage block, local storms, river spills etc. In view of the existence of large areas affected by drainage congestion in protected areas, it is important that information about such areas is reported separately. We, therefore, recommend that extent of the area affected by drainage congestion may be compiled separately for protected areas and unprotected areas.

9.10.3. While flood control and drainage schemes are prepared for part of river basins, damage data generally relate to a district or the State as a whole. It is necessary to compile such data by basins and/or sub-basins. This is not difficult as the basic data are collected village-wise and are readily available at the block level. This would require prior identification by the Flood Control Department of villages located in various river basins and sub-basins. It is, therefore, recommended that the Flood Control Department should mark out the boundaries of different river basins and sub-basins and pass on the information to the agency responsible for damage assessment.

9.11. Agency for collection and coordination of flood damage data

9.11.1. *Local level*: As indicated earlier, the responsibility for collection, compilation and coordination of data on flood damages at present rests primarily with the Revenue Departments. Generally this department has little interest in examining the suitability of the data for preparing flood control projects or for evaluating the effects of such projects. It is more interested in obtaining some preliminary estimates of flood damages as quickly as possible in order to administer relief measures, and after having undertaken such measures it may cease to take any further interest in finalising the figures. But from the point of view of flood control projects, an estimate of revised and final damages is needed. Again, for relief administration, it is not relevant to know whether the damage that has taken place is in protected or unprotected areas and whether it is on account of over-spill of the river, drainage congestion, rains or cyclones etc. But such considerations become important from the point of view of formulation of projects. Hence a suggestion that this work may be assigned to Flood Control Department has been made from time to time by some of the Committees mentioned in section 9.3.

9.11.2. The reason for entrusting the work to that department might have been dictated by the consideration that flood damage data are to be used by it for preparing flood control projects. From the point of view of the State Government, however, more immediate and important use of these data is in connection with revenue suspension/remission and relief administration handled by the Revenue Department. There should not be two agencies of the State Government for collecting the same data. The replies from States indicate that they would like the present arrangement of collection of data by the Revenue Department to continue. In most of the States, the revenue staff at the village level have traditionally been associated with collection of data on land holdings, crop areas, crop yields, prices etc. and are well equipped to do this work. These officials, being familiar with the layout of the concerned villages and being involved in the work of maintaining village statistics are no doubt in a better position than anybody else to make an intelligent guess about the extent of flooding and crop losses. Moreover, as the National Commission on Agriculture has observed, the association of revenue officials in the data collection has brought to bear upon the system of collection, the authority and prestige that is associated with the revenue agency in the villages. Besides, the integration of flood damage reporting with basic agricultural statistics at the village level proposed by us can only be brought about by the Revenue Department. We are, therefore, not in favour of entrusting this job to the Flood Control Department either at the State or lower level. We recommend that the flood damage statistics should continue to be collected as at present by the staff of the Revenue Department. We feel that a substantial improvement in collection of flood damage data is possible under the existing set up itself by adopting measures recommended earlier. Further improvement would be brought about by a more intensive supervision and better processing of data by the District Statistical Office.

9.11.3. However, collection of data relating to physical aspects of floods and related technical information should be the responsibility of the Flood Control Department these would include data on depth and duration of flooding, gauge and discharge, and preparation of flood maps for purposes of record. The Flood Control Department should also collect information on source of flooding which may be over-spill, breaches, drainage congestion or any other factor. It should endorse copies of reports, returns, maps etc., to the appropriate authority at the district level entrusted with the coordination of flood damage statistics.

9.11.4. *District level*:

Data collected at the village and block levels should be duly processed, scrutinised and consolidated at the district level. This work being statistical in nature, should be entrusted to the district Statistical Office which forms an integral part of the district administration. Moreover, being responsible for processing and publication of data on several other items some of which are related to the flood damage data, this department would be in a better position to provide appropriate check and supervision and thereby ensure higher reliability of data on flood damages. It may be mentioned here that the Government of Punjab (Revenue Department), by an order issued in July, 1978 has instructed the Deputy Commissioners to utilise the services of the Statistical Organisation in the district in this connection. We recommend that the Statistical Officer should get in touch with the concerned offices of the State Government at the district level as well as local offices of Central Government undertakings *e.g.* Railways, Post & Telegraphs and obtain damage data from them. It should look into supplementary information, if any, provided by the Flood Control Department on area flooded on the basis of contour maps, and on physical aspects of flood to scrutinise and reconcile the figures. Information provided by the remote sensing agency, if any, may also be used for scrutinising the data and improving the quality of reporting.

9.11.5. *State level*:

At the State level, the work of compilation and processing should be undertaken by the Directorate of Economic and Statistics. Information should be tabulated State-wise as well as river-basin and sub-basin wise. Information on damages in protected and unprotected areas may also be processed here. Copies of the final data for the State along with district-wise and basin-wise details should be sent to the Revenue, as also the Flood Control Departments of the State and to the Central Government.

9.11.6 *National level*

Damage data at the national level are compiled by the Central Water Commission. We would like this arrangement to continue. In view of the basically economic/ statistical rather than engineering nature of the work relating to compilation of damage data, we would suggest that the work of coordination at the national level should be handled by the already existing Directorate of Statistics of the Central Water Commission with an Economics Unit added to it. This Directorate should try to keep itself in touch with the State Governments, update the information whenever required and provide effective coordination between the Centre and the States with respect to reporting of final figures. It should publish data at the national level along with State-wise and important river-basin wise details. While doing so, it should bring out data according to the different classifications suggested earlier in para 9.10.1.

9.12. Other suggestions for improving the quality of data

9.12.1 *Time schedule for submitting final returns*

In order to systematise the work of data collection compilation and the publication of damage data, it is necessary to lay down a time schedule for submission of returns at various levels. While reporting during the floods may be arranged according to exigencies of the situation obtaining in particular areas, which is best left to block and district level administration to decide, annual estimate of crop damages for villages based on village records should be finalised by the end of kharif season and should reach district authorities by the end of December. The District Administration may work out a detailed time table for the block and sub-divisional levels in the light of the time limit indicated above. Flow of information from other concerned Departments of the States and Centre in the District should be so streamilined as to reach the district office by about the same time. Estimates of crop damages, damage to property etc. at the district level should be finalised in consultation with Flood Control Department, if necessary, and submitted to State level authorities by the end of February and from the State to the Centre by the end of March.

9.12.2 The improvement of data is a continuous process and would require sustained efforts. For this purpose it is suggested that at the State level there should be a periodical review of the methodology of data collection, compilation and publication by a Committee for Improvement of Flood Damage Data consisting of the concerned officers such as Revenue and Relief Commissioner, Director, Bureau of Economics and Statistics, Chief Engineer in charge of Flood Control, Director of Agriculture, etc. Some academicians and experts from outside the Government may also be associated with this work. The Committee should advise on matters of policy for bringing about improvements in the quality of damage data. It may, if deemed fit, also arrange for sample surveys to be conducted in specific areas for verifying the data collected in the normal course.

9.12.3 At the national level, the Central Water Commission should play the role of a catalytic agent in bringing about continuous improvement in the quality of flood damage data. Substantial progress in this direction would require sustained study of specific problems in depth by academicians and researchers. The Central Water Commission should, therefore, aid and encourage research in the methodology of flood damage assessment by giving research grants for specific research projects on the subject to universities and research institutions in the country, and by holding seminars, symposia, etc.

9.12.4 The present practice of grant of advance plan assistance on the basis of preliminary estimates of damages assessed quickly by hurriedly constituted Central Teams is not conducive to scientific assessment of flood damages. We would, therefore, recommend that the Central Water Commission should have the prime responsibility of scrutinising such data. And for this purpose, it should have permanent staff consisting of professional experts well versed in the intricacies of flood damage assessment.

9.12.5. A lot of improvement can be brought about if the finalisation of annual plans of States for flood control is made contingent on their submitting final figures of flood damages by the specified date. We recommend adoption of this measure.

ANNEXURE 9.1

Proforma I for Reporting Flood Damage at the Village level

Statement of flood damages for the year..................

Village........... *Tehsil/Block* .... *Sub-Division* .... *District* ....*State*....

total area affected hects.	population affected	crop stage* at the time of flooding (cropwise)	Crop area affecetd (hects.)				Crop yield Q/H			total value of crop damages 000 Rs.
			total crop area	crop area completely damaged	area resown replanted	area partially affected	partially affected crop	replanted crop	normally expected yield@	
1	2	3	4	5		7	8	9	10	11

House damage		lives lost	cattle loss		total damages (000 Rs.)
number	value (000 Rs.)	number	number	value (000 Rs.)	
12	13	14	15	16	17

सत्यमेव जयते

*Specify in terms of tillering stage or pre-flowering stage.

@average yield for the preceding five years.

ANNEXURE 9.2

Proforma II for Reporting Flood Damage at the Block/Tehsil Level and above

Statement of flood damages for the year..................

Village........... *Tehsil/Block* .... *Sub-Division* .... *District* ....*State*....

Blocks/ Districts	total area affected (000 ha.)	population affected (000)	damage to crops		damage to houses		human lives lost	cattle loss		damage to public utilities (000 Rs.)	total damages (000 Rs.)
			area (000 ha.)	value (000Rs.)	number	value (000 Rs.)		number	value (000 Rs.)		
1	2	3	4	5	6	7	8	9	10	11	12

X AREAS NEEDING URGENT ATTENTION

10.1. Introduction

We have given an analysis of available data on flood damages in the country in Chapter IV. We have indicated that the 5 major flood-prone States, namely Uttar Pradesh, Bihar, West Bengal, Orissa and Assam account for 66 per cent of the total affected and 61 per cent of the aggregate damages in the years 1971 to 1978. The States of Andhra Pradesh, Gujarat, Tamil Nadu and Rajasthan had some years of high floods in the seventies. Andhra Pradesh damage figures in 1976 and 1977 due to floods and cyclone, accounted for 23.9 per cent and 50.8 per cent respectively, of the aggregate damage in the country during these 2 years. The damage in Andhra Pradesh during 1977 was caused by a cyclone and floods, that caused by cyclone being about 67 per cent of the total damage in the State. Gujarat had accounted for more than 15 per cent of the aggregate flood damage in the country during 3 years in the seventies, of which the figures of 1979, are yet to be fully compiled. Rajasthan, a State of scanty rainfall and containing the only desert in our country, suffered high flood damages in 1973 and 1979. Tamil Nadu had flood damages of high magnitudes in the years 1972 and 1977, more than 10 per cent of the country's aggregate damages during these 2 years. Even States which did not account for a tangible percentage of the total flood damage during recent years, either due to their comparatively smaller sizes and/or on account of the flood problem not being extensive all over the State, may have some areas with acute flood problem, the intensity of which could be comparable to that of the recognised major flood-prone States.

The analysis of the damage caused by floods in recent years to identify areas needing urgent flood protection measures, thus was intended to cover all the States, irrespective of their overall proneness. We had also to keep in view the prevailing policy of funding the cost of ameliorative measures by the States affected by the specific flood problem. Under this policy, *inte se* priority between different areas in different States had no practical significance, as it was for each of the individual State to draw up its programme of ameliorative measures and take up for execution individual projects, entirely dependent on the internal resources of the State and the intent of the policy makers in the State, the acuteness or otherwise of the flood problem in any other area of any other State having no relevance.

The Questionnaire to the States sought lists of the areas which, in the opinion of the State Government, required urgent flood protection as also reasons therefor and details of the damages caused each year in these individual areas *vis-a-vis* the same in the State as a whole. The damage figures by themselves would not have given any indication as to whether the areas recommended by the States to be needing protection, were possible of protection by one or more of identified economically and technically viable ameliorative measures. We, therefore, also sought information about recommendations made by Committee(s)/Experts(s) on the suggested measures for amelioration, if any, in these areas and the details of action taken by the State thereon, like framing of specific projects, their construction being taken up or not, specific provision made for the projects in the State Plans and the status of implementation of the schemes.

We have formulated our suggestions based on the details furnished by the States and the recommendations of organisations like the Central Water Commission, the Ganga Flood Control Commission and the Brahmaputra Flood Control Commission.

10.2. Analysis of data and priority for attention

10.2.1 *Status of basinwise data*

Ameliorative measures against floods have to be planned basinwise. This makes it obvious that the basinwise flood damage data are needed for a meaningful appraisal of the intensities of flood damages during recent years for identification of basins/areas in the State/country needing urgent attention. The reliability of these basinwise flood damage data would dictate not only the merit of such identification but also the quality of appraisal of the benefits from the contemplated ameliorative measures in the basin.

Basinwise damage data were not furnished by some of the States. Our request to the States for giving us the basinwise flood damage data had been met by some of them by allocating the district/statewise damage figures to different river basins in the proportion of basin-wise areas of the district/State. This shortcut method presupposes a uniform intensity of flood damages in different basins within the districts/State, and thus vitiates the determination of the *inter se* intensity of basinwise flood damage.

The damage data, as compiled by the States was not listed according to the damage producing phenomenon *viz.* floods, cyclones, land slides and drainage congestion of surface drains. The damages caused by accidents like failure of a conservation reservoir which had no flood storage capacity, or failure of some flood control works, or even accidents of the nature of capsizing of a ferry boat were also included in the damage statistics of floods of some of the States. The generally accepted ameliorative measures will not be of help in some of these situations and only indirectly in others.

The methods of assessment and reporting flood damages are uniform by and large. There are, however, some exceptions like Gujarat which does not differentiate between the area affected and crop area affected.

We recognise the possibility that the intensities of flood damage within the same basin, could be different for different sub-basins. The likelihood of higher intensity of flood damage in a sub-basin than that represented by the average intensity of the overall basin is self-evident. Thus bigger the basin size adopted for working out the flood damage intensity, higher is the possibility of a sizeable sub-basin within it, having an intensity of flood damage much higher than the average of the large size basin. With this possibility, the data on flood damage in various basins, as furnished by different States were found to be on varying basins, some basins being of only a few thousand and some of several lakh ha. Thus, comparing average intensities of flood damages of such varying sized basins, tend to underrate the intensity of damage in sub-basins of larger basins as compared to the smaller basins of equivalent areas elsewhere.

A computation of basin-wise flood damage data in rupees per ha during the recent years for all the flood-prone river basins of the country, based on reliable comparable data would have been an index for identification of the areas with more acute flood problems which needed urgent attention. This could not be done, due to the various reason discussed above, particularly the absence of data from some of the States. The computation, if done, would also have had the limitations due to the doubtful reliability of the data and extreme divergence in the basin sizes on which average damages were worked out.

In view of the foregoing an attempt to identify the basins with most acute flood problem had to be given up.

10.2.2. *Recommendations of the States*

The recommendations of the States about areas needing urgent attention were so extensive that had we endorsed these in totality, it would have defeated the purpose behind our recommendations. While we feel that all flood-prone areas should receive attention, we realise that this is not possible of immediate achievement. Based on the recommendations of the States, we have, however, attempted to summarise the more important areas. We admit the possibility of some omissions even in the States recommendations. Thus, for example, the acute flood problems of the Mahananda basin in Bihar and West Bengal, did not find a place in the Statewise compilation of the High Level Committee on Floods 1957. In a similar manner, it is possible that despite the exhaustive lists furnished by the States, some areas with acute flood problems may have been overlooked. It is also possible that due to changes in river course, avulsion of a river into another basin, or some natural phenomenon like land slides and earthquakes, a hitherto unaffected area may become flood-prone in the future.

The organisations like the CWC, the GFCC and the BFCC have benefited us with their general recommendations about areas/measures needing urgent attention. While we generally agree with these recommendations, we feel that these suggestions may be taken to be only an indication of the possible priority to be given by the States in matters of investigations of projects for ameliorative measures. The States should however have the discretion to take up investigations and framing up of projects for areas besides those indicated in our Report.

10.3 **Criteria**

10.3.1 *Economic consideration as a criterion*

In Chapter XIV we have mentioned that some of the State Governments have indicated that protection measures for the areas threatened with immediate danger to life and property and those intended to protect areas where floods and damage are severe should receive priority. We have, however, felt that the State Governments have not always adhered to the above-stated principles and that priorities of schemes changed some times with the change of political spheres of influence. We have also gathered the impression that the process of selection of emergent schemes depended largely on the subjective judgment of the executive agencies and decision makers. We have felt that flood being an emergency phenomenon, any sort of scheme can be given a justification (not necessarily genuine) for being taken up as an emergent scheme, so much so, that costly schemes with doubtful economic viability have at times been taken up to save private agricultural land of nominal value as compared to the cost of such protection. We have, therefore, opined that the criteria of giving priority to 'emergent' schemes is fraught with the risk of misuse, due to the reason that the criteria of being called 'emergent' can be stretched to apply to almost any and every flood control project. We have, therefore, recommended that a rational choice should be made from schemes amongst a shelf of detailed investigated projects according to the criteria of benefit-cost ratio, the greater the ratio, higher being the priority.

This recommendation to a certain extent would also meet the requirement of giving priority to areas where flood damages are more severe, because, benefit from a project would be more where damages were relatively more prior to the execution of the project. However, the corresponding cost of ameliorative measures, if disproportionately high compared to even this high benefit, would reduce the benefit-cost ratio to some extent. Similarly, the requirement, that the areas threatened with immediate danger should receive priority would also be met to a certain extent, by the benefit-cost ratio criteria, as avoidance of a large scale calamity would enhance the estimated benefit considerably, and thus the benefit-cost ratio and the consequent priority.

10.3.2 *Physical characteristics of the protected object as a criterion*

In Chapter XIII we have indicated that the physical criteria for giving priority could be limited only to schemes for the protection of religious and historical monuments and places of strategic importance, because the intrinsic value of those could not be converted into mere financial terms. These physical criteria have to be applied only rarely and with due restraint, as otherwise, it may not be impossible, that merely for getting priority structures like temples may be constructed overnight at the edge of private land threatened with erosion. The cost of shifting, where feasible, should always be considered as an alternative.

10.3.3 *Physical dimensions of flood and its duration as a criterion*

The frequency, depth and duration are important parameters for evaluating the acuteness of flooding in physical terms. Their application has, however, relevance mainly to the flood damages, or rather as a constraint to deriving the maximum use of the potential resources of the land. An island, in the process of formation in the deltaic reach of a river, may, for example, have a high frequency, deptn and duration of flooding, but it is obvious that, there is no question of giving priority for the flood protection scheme for such an island. Thus the past flood damages and the potentiality of a flood affected area, for rendering developmental benefits after flood protection, should be considered to be more important than the mere physical dimension and durations of floods.

10.3.4 *Implications of our term of reference*

Our fourth term of reference is "to analyse the damage caused by floods in recent years and to identify the areas requiring immediate flood protection measures". The areas needing urgent attention is thus, as per our term of reference, related to the analysis of damage caused by floods in recent years. We have endeavoured to do so, as far as possible, despite the paucity of dependable data on flood damages, that was available to us, from various sources. We, however, still hold the view that rational choice in deciding interse priority of projects should be with due consideration of the criteria of benefit-cost ratio. Our recommendations, with regard to areas needing urgent attention, which are mostly without any detailed examination of the technical and economic viability of the projects, it any, proposed in these areas and they merely indicate the need of urgent attention for investigation of the proposed flood control measures. Our recommendations thus merely stress the need for investigation and finalisation of the project reports and estimates after the same, so that the eventual technically feasible schemes drawn up in conformity with the future approach outlined in Chapter XI, and get appropriate priorities as per the criteria recommended in Chapter XIII.

10.4. Damages caused in recent years

10.4.1 *State-wise damage figures*

The figures of average annual flood damages during the period 1966—78 in the various States are listed below, for the States where the average loss has exceeded Rs. 1,000 lakhs.

Table I—Annual Food damage during 1966—78

Sl. No.	Name of the State	Annual damage in lakh Rs.	As percentage of the total in the country
1	Bihar	10,704	22.8
2	Andhra Pradesh*	8,306	17.7
3	Uttar Pradesh	6,914	14.7
4	West Bengal	4,569	9.7
5	Gujarat	3,120	6.6
6	Orissa	2,303	4.9
7	Rajasthan	2,049	4.4
8	Tamil Nadu	1,631	3.5
9	Haryana	1,625	3.5
10	Assam	1,271	2.7
11	Kerala	1,142	2.4
12	Total for the country	46,952	..

*Includes figures of damages caused by cyclones.

The figures above for Andhra Pradesh and Tamil Nadu also include the damage caused by cyclone. It has been reported that out of Rs. 66,854 lakhs of damages in Andhra Pradesh during 1977, the damage caused by the cyclone was as high as Rs. 44,180 lakhs or approximately 67 per cent. The attention needed for ameliorating the problem of cyclone damages will be of a category different from those affected by floods. This fact has, therefore, to be kept in mind in the case of Andhra Pradesh and Tamil Nadu.

10.4.2. *Statewise figures of areas affected*

The figures of average annual area affected during the period 1966-78 are given in the table below for the States with the average annual area affected exceeding one lakh ha.

Table II—Annual area affected during 1966—78

Sl. No.	Name of the State	Average annual area affected in lakh ha.	State figure as a percentage for the country
1	Uttar Pradesh	26.20	25.1
2	Bihar	17.27	16.5
3	West Bengal	11.98	11.5
4	Assam	8.98	8.6
5	Orissa	6.97	6.8
6	Andhra Pradesh	6.77	6.5
7	Rajasthan	6.28	6.0
8	Madhya Pradesh	5.75	5.5
9	Gujarat	3.66	3.3
10	Kerala	3.47	3.3
11	Haryana	2.90	2.8
12	Punjab	1.00	0.96
13	Total for the country	104.46	

10.4.3. *Statewise population affected figures*

The average annual population affected during the period 1966-78 are given in the table below, for those States where the annual average of the population affected exceeded 10 lakhs.

Table III—Annual population affected during 1966—78

Sl. No.	Name of the State	Average annual population affected in lakh	State figure as a percentage of the country
1	Uttar Pradesh	89.42	23.1
2	Bihar	85.43	22.1
3	West Bengal	48.05	12.4
4	Tamil Nadu	30.55	7.9
5	Orissa	26.41	6.8
6	Andhra Pradesh	24.78	6.4
7	Assam	18.83	4.9
8	Gujarat	16.51	4.3
9	Kerala	12.00	3.1
10	Rajsthan	11.97	3.1
	Total for the country	387.26	

10.4.4. *Ranking of States as per flood damage statistics*

The overall relative ranking of the flood problem in the States, on the basis of annual flood damage, area affected and population affected, as per the annual averges of the figures listed in Tables I, II and III (if we give equal weightage to these three aspect of the flood damages) is given in the table below.

Table IV—Statewise ranking of flood damage

Sl. No.	Name of the State	Ranking of basis of annual averages of 1966—78			Total of rank No.	Ranking of State in order of flood damage
		Total damage	Area affected	Population affected		
1	Bihar	1	2	2	5	Bihar
2	Andhra Pradesh	2	6	6	14	U.P.
3	Uttar Pradesh	3	1	1	5	W. Bengal
4	West Bengal	4	3	3	10	A. Pradesh
5	Gujarat	5	9	8	22	Orissa
6	Orissa	6	5	5	16	Assam
7	Rajasthan	7	7	10	24	Gujarat
8	Tamil Nadu	8	12	4	24	Rajasthan
9	Haryana	9	11	+10	+30	Tamil Nadu
10	Assam	10	4	7	21	Haryana
11	Kerala	11	10	9	30	Kerala
12	Madhya Pradesh	11+	8	+10	+29	M.P.

The overall position of the magnitude of the flood damage problem in the States, has also to take into account the inclusion of the damage caused by cyclone in the figures of flood damage for Andhra Pradesh and Tamil Nadu and with due consideration to this the States needing urgent attention can be classified as under:

I	First priority:	Bihar, Uttar Pradesh, West Bengal, Orissa, Assam.
II	Second priority:	Gujarat, Andhra Pradesh, Rajasthan, Kerala, Haryana, Tamil Nadu.
III	Third priority	. Rest of the flood affected States and Union Territories in the country.

States which did not account for tangible flood dagages may also have some areas having actue flood problem needing urgent attention.

10.5. Statewise assessment of areas needing urgent attention

The statewise assessment of areas needing urgent attention, for the States, deserving specific discussion are given in Annexure I. For convenience, the States have been dealt with in the alphabetical order.

सत्यमेव जयते

ANNEXURE I

Andhra Pradesh

A. *Past flood damage data*

In the analysis of flood damage statistics made earlier, it is seen that Andhra Pradesh had some years of high floods in the seventies and it ranks second in repect of the annual flood damage (including damage due to cyclone) among the flood affected States and ranks number four in the order of flood damage magnitude (Table IV). Within the State the Godavari and Krishna basins have recorded the maximum crop damage intensities. Since these two river basins account for the maximum flood damages in the State, the specific areas district-wise within these basins where flood damages have been recurring are tabulated below in the decending order of incidence as per the information of damages (1966-73) furnished by the State Government.

Sl. No.	Name of the District	No. of years for which data available	No. of years floods where experience
1	Khammam District (East & West Godavari district (Part) (Godavari basin) . . .	8 years	6 years
2	Mehboobnagar, Nalgonda, Krishna and Guntur district (Krishna basin) . . .	8 years	6 years
3	Nellore & Cuddapah district (part) (Pennar basin) . .	8 years	5 years
4	Srikakulam (Part) (Nagevali basin) . . .	8 years	5 years
5	East Godavari district. . . (Yeleru basin) . . .	8 years	3 years
6	Srikakulam (Part) (Vemsadhara basin) . . .	8 years	2 years

सत्यमेव जयते

B. *State's proposals*

The State Government has given 2 lists of schemes—one list for areas needing urgent flood protection works (53 schemes), and another list of 28 schemes which require flood protection works to be completed on priority within 2 or 3 years and finalised by the State Flood Control Board in its meeting held on 26-8-77. Most of the 28 schemes listed by the State Flood Control Board find a place in the first list also. In this list there are 8 schemes in Godavari basin, 6 schemes in Pennar basin, 2 schemes in Nagevali basin, 1 in Sarda basin and 3 in Varaha basin.

C. *Suggestions*

From the study of the flood frequency over an 8-year period in para A above, it is seen that the Khammam district and parts of East and West Godavari districts in the Godavari basin and the Mehboobnagar, Nalgonda, Krishna and Guntur districts of the Krishna basin suffer more frequently from floods and hence require urgent attention. Fourteen of the 28 schemes identified by the State Flood Control Board for priority execution fall in these 2 basins.

Assam

A. *Past flood damage data*

In the analysis of damage data statistics, Assam ranks sixth in the order of flood damage magnitude. According to the report of the State Government, all the 7 districts of Brahmaputra valley and the districts of Cachaar in the Barrak valley are inundated almost every year. The incidence of flooding as furnished by the State Government, are as under:

Sl. No.	Name of district	No. of years for which damage data available 1966-77	Frequency of floods during the period 1966-67
1	Sibsagar	10	10
2	Nowgong	10	10
3	Lakhimpur	10	10
4	Darrang	10	10
5	Kamrup	10	10
6	Goalparax	10	10
7	Cachar	9	9
8	Dibrugarh.	9	9

Note: Damage data for Assam for individual districts is not available for 1967 and 1968. Damage data for Dibrugarh and Cachar not available for 1971 and 1972 respectively.

B. *State's proposals*

The State has given specific recommendations regarding stabilisation of the existing works, their extension and anti-erosion works both for the Brahmaputra and the Barrak valleys. The extensive nature of the damages of the different districts are shown in the statement furnished below:

Name of district	Area of the dist. lakh/ha	Areas flooded in lakh hax 1966	1972	1977	Average damage	% of dist. areas
Sibsagar	8.99	2.79	1.19	5.43	3.14	34.89
Lakhimpur	5.65	1.19	1.94	2.23	1.78	31.62
Cachar .	6.88	2.83	2.64 (1976)	0.88	2.12	30.76
Kamrup .	9.86	4.57	1.23	1.54	2.44	24.81
Nowgong	5.56	0.92	0.62	1.68	1.07	19.24
Darrang .	8.78	1.86	0.92	1.38	1.38	15.71
Goalpara	10.36	2.14	0.97	0.27	1.12	10.87
Dibrugarh	7.02	1.49	0.15	0.05	0.68	9.74

Note: The extensived amages to Sibsagar district in 1977 due to breaches have pushed up Sibsagar district otherwise Lakhimpur and Sibsagar are to be treaetd equally.

The proposals of stabilisation, extension and anti-erosion works are in the same aras where damages are frequent and extensive according to the tables given above under paras A and B.

C. *Suggestions*

The entire Brahmaputra and Barrak valleys have recurrent and intensive flood damage problem which need urgent attention.

Bihar

A. *Past flood damage data*

This is one of the major flood-prone States of the country. In recent years of 1974 and 1975 it represented 67.1 per cent and 56.5 per cent of the total flood damages in the country. The abstract of past damage data is as under:

Period	Annual average	Max in a year
(a) Total area affected lakh ha		
1950-65	8.81	25.0
1966-70	10.82	15.3
1971-78	21.30	42.6
(b) Crop area affected lakh ha		
1950-65	4.43	15.9
1966-70	5.85	11.2
1971-78	8.85	15.4
(c) Damange to crop lakh ha		
1950-65	797.41	2751.42
1966-70	1046.42	2054.79
1971-78	2723.69	7039.74
(d) Total damages lakh Rs. at constant price		
1950-65	861.92	3453.17
1966.70	1184.08	2128.82
1971-78	4588.57	10043.03

B. *State's proposals*

Out of the 22 river basins 14 are affected by flood repeatedly. These 14 basins are listed below:

1. Gogra basin
2. Gandak basin
3. Burhi Gandak basin
4. Bagmati and Adhwara basin
5. Kamla basin
6. Kosi basin
7. Mahananda basin
8. Karmanasa basin

8A. Minor streams flowing directly into the Ganges

9. Sone and North Koel basin
10. Kiul and Harohar basin
11. Badua basin
12. Chandan basin
13. Chir and other river flowing directly into the Ganges
14. Punpun basin

The first 7 basins are in North Bihar, the rest 8 are in South Bihar. North Bihar has the misfortune of facing worst flood ravages very often, due to the spilling of its rivers and their numerous tributaries. This flood gets accentrated all the more due also to the fact that the river bed levels have shown a trend to rise. So far as South Bihar is concerned the floods are less frequent than those in North Bihar.

The above named 15 flood-prone basins lie in the districts (1) Gopalganj, (2) Siwan, (3) Chapra, (4) West Champaran, (5) East Champaran, ((6) Muzaffarpur, (7) Vaishali, (8) Sitamarhi, (9) Darbhanga, (10) Madhubani, (11) Begusarai, (12) Samastipur, (13) Saharsa, (14) Purnea, (15) Katihar, (16) Bhagalpur, (17) Monghyr, (18) Bhojpur, (19) Rohtas, (20) Patna, (21) Nalanda, (22) Gaya, and (23) Aurangabad.

In the opinion of the State Government the above named 15 basins need urgent flood protection with the priority that the first 7 basins lying in North Bihar need utmost urgent attention and the rest 8 basins although need urgent attention at par with the North Bihar river basins, may be given a second priority.

C. *Suggestions of the G.F.C.C. on the State's recommendations*

As regards Bihar, the GFCC concurs with the views of the State as mentioned above with regard to areas needing urgent attention. Priority areas based on flood damage statistics have been worked out and given below in order of priority.

Sl. No.	Name of the district	No. of years for which data available	Frequency of floods in the period 1968-76
1.	Saharsa	9 years data for the period 1968-76	8
2.	Darbhanga	Do.	8
3.	Muzaffarpur	Do.	8
4.	Monghyr	Do.	8
5.	Purnea	Do.	8
6.	Chapra (Saran)	Do.	7
7.	West Champaran (Bettaih)	Do.	7
8.	Santhal Pargana	Do.	6
9.	Bhagalpur	Do.	6
10.	Bhojpur (Shahabad)	Do.	5
11.	Katihar	Do.	4
12.	Madhubani	Do.	4
13.	Sitamarhi	Do.	4
14.	Vaishali	Do.	4
15.	Samastipur	Do.	4
16.	Begusarai	Do.	4
17.	Patna	Do.	4
18.	Palamau	Do.	4
19.	Gopalganj	Do.	3
20.	East Champaran (Motihari)	Do.	3
21	Gaya	Do.	3
22.	Siwan	Do.	2
23.	Rohtas	Do.	2
24.	Nalanda	Do.	1
25.	Aurangabad	Do.	1

Delhi

A. *Past flood damage data*

The flood damage statistics during 1955 to 1978 indicate an average damage of Rs. 123 lakhs with the maximum damage being Rs. 1761 lakhs during 1978. The availabe statistics also show that during the years 1977 and 1978 Delhi had experienced the severest floods and consequent heavy damages.

In the Year 1978, the Union Territory of Delhi suffered heavy damage due to an unprecedented flood in the river Yamuna when the high flood level recorded at the old railway bridge surpassed all previous records. A number of embankments in the northern parts of Delhi breached and there was extensive damage and distress in both agricultural area and urban colonies such as Jahangirpuri, Model Town, Adarsh Nagar, etc.

Serious drainage congestion occurred in Najafgarh Block area in 1964, 1967, 1977 and 1978 due to heavy floods in the Sahibi Nadi. The 1977 floods in the Sahibi were the worst in living memory. The Dhansa Bund was outflanked and it is estimated that a peak discharge of 33,000 cusecs flowed into Delhi U.T. compared to the discharging capacity of 3000 cusecs in Najafgarh drain. The accumulated flood waters took over three months to drain out.

B. *Suggestions*

Areas needing urgent attention on the basis of the experience of the heavy floods described above are as follows:

(i) Areas on the right bank of the Yamuna such as Shalimar Bagh, Adarsh Nagar, Model Town, etc. which suffered damages during 1978.

(ii) Areas in the Najafgarh and Kanjhawala blocks affected by the Sahibi Nadi floods in 1977, especially areas near villages Mundela Kalan and Mundela Khurd.

(iii) Unauthorised or recently regularised colonies in low-lying urban areas, especially those on the east of the river Yamuna which suffer from drainage congestion during spells of heavy rain.

Urgent attention also needs to be given to the laying down and enforcement of measures for regulating development in rural areas protected by embankments so that there is no undue increase in damage and loss of life in the event of breaches in the embankments due to the occurrence of a flood higher than the design flood, or by other unforeseen causes such as river erosion, etc.

ujarat

\. *Past flood damage data*

The State Government has furnished flood lamage data regarding areas needing urgent ıttention for the Years 1970, 1973, 1975, 1976 and 977. This information has been analysed in resject of damage intensity on cropped area and requency of flood incidence which indicates the ollowing order of priorities for areas needing ırgent attention.

	Districts		River Basin	Intensity of damage (average annual damage/ average cropped in ha. (5 year period)	Frequency of flood damage (5 year period)
1.	Bharuch	.	Narmada]	444	5
2.	Vadodars	.	Viswamitry, Mahi Dhadar, Narmada	495	5
3.	Kheda	.	Mahi and Sabarmati	444	5
4.	Mehsana	.	Sabarmati, Saraswati and Rupen	544	4
5.	Ahmedabad	.	Sabarmati	547	4
6.	Surendra-] Nagar	.	Sabarmati, Bhogavo Bhadar	52	4
7.	Sabarkantha		Sabarmati, Harnav, Hathmati	854	4
3.	Banaskantha	.	Banas	299	4
9.	Gandhinagar		Sabarmati	573	3
0.	Rajkot	.	Bhadar and its trihutary	277	3
1.	Surat .	.	Tapi and Mindhola	933	3
2.	Valsad	.	Ambica, Auranga, Purna, Mindhola	978	3
3.	Bhavnagar	.	Padalio, Kheri, Ghelo, Rangoli, Kolubhar	1716	2
4.	Junagadh	.	Ozat, Mihsar, Sabli, Bhadar	47	2
5.	Amreli .	.	Shetrunji and Streamlet	46	1
6.	Jamnagar	.	Ghee, Soni, Fulzar, Aji Und	1882	1

3. *State's proposals*

The State Government has indicated, basinvise priorities for areas needing urgent attenion as under:

(a) Narmada basin

(b) Tapi basin

(c) Vishwamitri Dhadhar basin

(d) Mahi basin

(e) Sabarmati basin

(f) Group of other river basins of Gujarat region

(g) Group of other river basins of Saurashtra region

(h) Ghed area of Saurashtra region

(i) Drainage area of districts of Mehsana, Gandhinagar, Ahmedabad and Kheda.

They have further listed the schemes for flood control in the above areas under three groups, viz.—

(1) spill over schemes-areas (b), (c), (h), (i)

(2) schemes for protection against bank erosion and preventing meanders-areas (d), (e), (f) and (g)

(3) Small schemes of district Panchayats-areas (f) and (g)

The Narmada basin schemes had not been included in the above grouping as no protective work on large scale had been planned so far due to the Narmada water dispute.

C. *Suggestions*

The analysis of flood damage data in para A is a definite pointer to the fact that the districts of Bharuch and Vadodara in the Narmada basin. Mehsana, Ahmedabad and Gandhinagar district in the Sabarmati basin, Kheda district falling under the Sabarmati and Mahi basins suffer frequently from floods and therefore require urgent attention. This view is more or less in agreement with the State Government's recommendations. It is also our view now that the Narmada water dispute has been settled flood protection schemes in the districts of Bharuch and Vadodara should be planned and executed on a priority basis. In other priority districts identified above, there are a number of on-going schemes of town protection, river training and drainage improvement which need to be completed.

Haryana

A. *Past flood damage data*

In the State Governments replies flood damage statistics though available since 1953 have not been analysed district-wise or basin-wise. However, a general analysis of damage data for the period 1953—78 shows that the annual damage is Rs. 10.7 crores and the maximum damage of Rs. 71 crores occurred only recently in the year 1977. Compared to the previous years, the area affected by floods during the years 1977 and 1978 has been very large, being 10.00 lakh ha (max.) during 1977 and 7.1 lakh ha. during 1978.

B. *State's proposals*

The State Government has specifically identified the problem of drainage congestion in the following areas for which remedial measures are urgently required:

- (i) Areas of Pakasma and West Jua System
- (ii) Areas on proposed Kultana-Ghhudani-Bhupania drain
- (iii) Areas on outfall Drain No. 8
- (iv) Areas on tributary drains 1, 2, 3 and 4
- (v) Areas on Chhapra drain, Bhambasa drain, Dubetta drain, East Jua and West Jua drain
- (vi) Areas on Pundri drain
- (vii) Mewat area
- (viii) Jhajjar area

The State Government has stated that the drains in the above mentioned areas exist but are of inadequate capacity. Further, there are some low-lying areas which cannot be drained by gravity. They have also mentioned that areas also suffer due to spills from the Sahibi, the Yamuna, the Saraswati, the Tangri, the Markenda and the Ghaggar rivers for which remedial measures in the form of remodelling of existing drains, preventing spills from the rivers, installation of pumps to drain low-lying areas and construction of bunds to protect villages are required.

Apart from the areas mentioned above, the State Government has referred to proposals, contained in the Master Plan/Action of 1977 under which schemes to be completed in a period of 5—7 years starting from 1977-78 have been identified. The priority schemes identified in this master plan are as below:

- (i) Ujjina Diversion Drain
- (ii) Chhudani-Bhupania Drainage complex
- (iii) Bahadurgarh area drainage improvement
- (iv) Pundri drain
- (v) Remodelling of Gaunchi main drain
- (vi) Remodelling of Diversion Drain No. 8
- (vii) Remodelling of Pakasma and West Jua System
- (viii) Jhajjar ring bund with its outfall drain
- (ix) Raising and strengthening of left bank of outfall drain No. 8
- (x) Construction of Masani Barrage on river Sahibi
- (xi) Kotla lake storage project
- (xii) Bhindawas lake storage project
- (xiii) Raising of pond level of Ottu weir
- (xiv) Construction of ring bunds around marooned villages

C. *Suggestions*

In the absence of detailed analysis of flood damage data district-wise/basin-wise, the assessment of areas needing urgent attention has been made only on the basis of the schemes listed by the State in their replies. We would like to suggest the following priority for finalising the schemes:

- (i) Flood protection schemes in the Yamuna the Sahibi and the Ghaggar basins after due approval by their respective standing committees.
- (ii) Inter-State drainage improvement schemes subject to drainage arrangements and construction programmes being agreed upon by the downstream riparian States.
- (iii) Schemes for improvement of drainage in the districts of Rohtak, Panipat Sonepat, Ambala and Gurgaon.

Himachal Pradesh

A. *Flood damage data*

As per the overall flood statistics from 195 to 1978, the damage to crops and houses in the State has been rather small, the average cropped area affected being 10,000 ha with a maximum of 1.3 lakh ha in 1971. The State Government has not furnished detailed damage data district-wise or basin-wise.

B. *State's proposals*

Even though the State Government has not identified specific areas needing urgent attention, a few schemes envisaging the construction of embankments and river bank protection works to protect localised areas and properties like buildings, houses, etc. have been ideniified These are as under:

- (i) *Sutlej basin*—Una district
  7 embankment schemes, 11 river training works
- (ii) *Beas basin*
- (a) Kangra district: 2 embankment schemes 8 river training works
- (b) Mandi district: 4 river training works

C. *Suggestions*

As the State does not have any significant flood problem the schemes listed in para B above should be finalised.

Jammu and Kashmir

A. *Past damage data*

The State Government has indicated the break-up of damages districtwise for 2 years i.e. 1959 and 1973 when the damage has been very severe. Over a period of 25 years from 1954—78 the average annual damage has been estimated as Rs. 129 lakhs and this average mark has been exceeded only in 4 years namely 1959, 1973, 1975 and 1976, the damage being maximum Rs. 1287 lakhs during 1973. On the basis of district-wise break-up of cropped areas affected in the 2 high flood years of 1959 and 1973 the following priorities emerge:

District	Croped area affected (ha)
1. Baramulla	22220
2. Anantnag	15540
3. Srinagar	10780
4. Jammu	1760
5. Poonch	940
6. Udhampur	940
7. Doda	770
8. Kathua	590
9. Rajori	60
10. Leh	20

B. *State's proposals*

In the State Government note under the heading 'Future proposals', the recommendations of high-level Flood Committee (which was accepted by the State Flood Control Board in December 1976) have been listed as follows:

1. Improvement of flood spill channel
2. Detention basins above Srinagar
3. Improvement of river through city and city channels
4. (i) Outfall channel improvements
   (ii) Procurement of Dippu Dredger Unit
5. Raising and strengthening of embankments **from Sangam to Srinagar** with a top of width of 12 to 15 ft. and free board of 5 ft.
6. Ultimate solution of the flood problem by diversion of excess water of the river from Dogripora to Wullar lake through a supplementary channel with an interim measure of providing detention basins.

All the above recommendations pertain to the Jhelum Valley.

C. *Suggestions*

The analysis of flood damage data indicates that the three districts of Baramula, Anantnag and Srinagar in the Jhelum Valley are the areas needing urgent attention. The schemes suggested by the State also fall in these districts. In our view Srinagar city is the most important area which needs priority attention. Agricultural areas upstream and downstream of Srinagar should be provided limited protection only against low floods and during high floods, inundation of such areas helps to reduce the flood threat to Srinagar city.

Karnataka

A. *Past flood damage data*

Flood damage statistics have been supplied for the whole State and not district-wise or basin-wise. The flood damage is also not much. The flood problem in the State is not severe as the rivers generally flow within well-defined banks. However, there are occasions when storm rainfall of high intensity results in some local flooding.

In the coastal districts of Uttar Kannada and Dakshina Kannada floods of damaging proportions are quite frequent due to spilling over banks. During the 1974 floods, which were considered very severe, the damage caused was estimated at Rs. 5.16 crores. Beach erosion has also been reported in certain stretches of the 300 km long coast line of the State, particularly at river mouths.

B. *State's proposals*

The State Government has mentioned only 2 small schemes, both in Dakshina Kannada district. Both the bank protection schemes are under consideration of the State TAC (Floods).

The State Government has also given a supplementary note and emphasised the urgent need for providing protection against beach erosion so that a stable coast-line is maintained to ensure increased tempo of economic activity along the coast.

C. *Suggestions*

The areas and schemes identified by the State Government in the Dakshina Kannada district merit urgent attention. The beach erosion problem also needs attention.

Kerala

A. *Past damage statistics*

The State Government has furnished damage statistics for all the river basins of the State for 2 years only i.e. 1961 and 1962, even though it has been stated that the damage during the last 10 years has shown an increasing trend. The flood damages in the State as a whole have been mainly due to cyclones. The damage statistics for the whole State indicate a trend of recurrent damage since 1968 with a maximum damage of Rs. 7465 lakhs during 1978. The average annual damage during 1956 to 1978 is Rs. 656 lakhs. As per the damage data furnished for the years 1961 and 1962 by the State, the basins where the damage has been above Rs. 5 lakhs, are tabulated below:

River basin	Total annual damage in Rs. lakhs
1. Periyar	40
2. Bharathspuzha and Tirur	35
3. Karuvanur	31
4. Achenkovil	13
5. Keecherry	12
6. Kallai	11
7. Valapattanam	9·77
8. Kadalundry & Poorapuzha	9·20
9. Pamba	7·00
10. Chalakudy	6·00
11. Kallada	6·95
12. Muvattupuzha;	5.00

B. State's proposals

The State Government has indicated 32 river/stream basins, for which flood damage statistics for the year 1961 and 1962 have been furnished, as areas needing urgent attention. Details of schemes to be constructed have not been furnished though it has been stated that a long range plan has been drawn up.

C. Suggestions

On the basis of analysis made in para A above areas affected by floods in the first 6 river basins viz. Periyar, Bharathapuzha and Tirur, Karuvannur, Achenkovil, Keecherry and Kallai may be considered for priority attention.

Madhya Pradesh

A. *Past flood damage data*

The State is not subjected to devastating floods, as are commonly witnessed in some of the neighbouring States, like Uttar Pradesh and Bihar. Although floods in Madhya Pradesh rivers are of high intensity, their duration is short. Submergence of low-lying areas close to the river banks does take place occasionally, causing damage to crops and loss of human and animal life, etc.

In the Narmada basin flood damages have bee severe in certain years due to high intensity rain fall and consequent high floods causing inunda tion of many towns and villages. There wer unprecedented floods in the Narmada river in th year 973 which created havoc in towns an villages in the districts of Hoshangabad, Sehore and Khargone. Hoshangabad town itself suffer ed heavy flood damage; the total loss on accoun of this flood was estimated as Rs. 31.87 crores.

In the Chambal and Betwa river basins heav flood damage occurred during the year 197 affecting several districts including Vidisha an Bhopal.

B. *State's proposals*

The State Government has indicated the following as the areas needing urgent attention:

(i) The Mandla town affected by silting o the open channel;

(ii) Jabalpur town affected by drainage congestion of Motia and Omta nallahs; and

(iii) Hoshangabad town due to inadequate embankments.

The State Government has suggested 9 schemes in all for protection to areas needing urgent attention and these are said to be awaiting clearance by the State Flood Control Board.

C. *Suggestions*

Detailed basin-wise/district-wise break-up for the areas affected in various years is not available. In its absence, areas which have suffered heavy damage during past floods in the Narmada valley and in the Chambal and Betwa river basins as mentioned in para A above need attention on a priority basis.

Maharashtra

A. *Past flood damage data*

The problem of floods is not severe in this State nor do floods inundate large or extensive areas of land. The damage statistics do not indicate any areas needing urgent attention and no major flood control measures have been found necessary.

B. *State's proposals*

The State Government has not identified any areas for urgent attention as there is no severe flood problem in the State.

C. *Suggestions*

Heavy rain and floods in August 1979 caused extensive damage in the Vidharba region of the State. The areas badly affected may be considered by the State Government for attention.

Orissa

A. *Past flood damage data*

From the analysis of flood damage statistics of States given earlier, Orissa State occupies the fifth position in the order of flood damage magnitude and crop damage. The damage statistics furnished by the State for areas needing urgent attention have been analysed as under:

River basin	Area flooded in ha.	Area affected by drainage congestion in ha.	Area affected by saline inundation in ha.	Frequency of flood/ drainage congestion (10 year period)	Overall ranking drainage
1. Baitarni	98834(1)	21990(4)	38125(2)	7(2)	(1)
2. Brahmani	70215(2)	33360(2)	24450(4)	7(2)	(2)
3. Sbarnarekha	52706(3)	26550(3)	25690(3)	81(1)	(2)
4. Doab 'B' Balanga & Baitarni	24087(4)	21990(5)	2672(5)	—(4)	(3)
5. Burhabalanga	13623(5)	6605(6)	4273(6)	3(3)	(4)
6. Mahanadi	5902(6)	110865(1)	108184(1)	(1)	(1)

The figures in parenthesis indicate the ranking of the basin in respct of the particulars given in each column.

A combination of the statistics indicates that the river basins of Mahanadi, Baitarni, Brahmani and Subarnarekha have recurring flood and drainage problems including saline inundation resulting in heavy damages.

B. *State's proposals*

The State Government has identified the following areas as requiring attention:

(i) Doab of Brahmani

(ii) Doab of Baitarni

(iii) River basin of Subarnarekha

(iv) Upper reaches of Brahmani and Mahanadi rivers and their tributaries

(v) Areas in the coastal belt subject to saline inundation.

The State Government has also suggested greater emphasis with larger provision of funds for the deltaic region *i.e.* from the delta-head upto the outfall point into the sea where the problems of flooding, bank erosion saline, inundation and drainage congestion are more frequent.

C. *Suggestions*

From the analysis made in Part A it is suggested that areas in the Mahanadi basin which suffer mainly by drainage congestion and saline inundation, the Baitarni basin where the damage is mostly due to floods and saline inundation and in the Brahmani and Subarnarekha basins where the damage is due to floods, drainage and saline inundation need urgent attention.

Punjab

A. *Past flood damage data*

The State Government has furnished damage statistics in a general way not for any particular year for the districts of Ferozepur, Faridkot, Ludhiana and Sangrur in the Sutlej basin, the Ajnala Tehsil of Amritsar district in the Ravi basin.

B. *State's proposals*

The State Government has indicated the following measures to be taken up on priority:

1. Flood protection measures from Nangal to Rupar on Sutlej river.
2. Flood protection measures on Hoshiarpur Choes (hill torrents).
3. Flood protection measures at Harike head works on Beas river.

The following schemes have been listed under urgent flood protection works taken up or proposed:

1. Patiala district-Ghaggar tract
   Embankment/bund schemes .. 1
   Drainage scheme 1

2. Rupar, Ludhiana and Ferozepur districts in Sutlej river basin
   Embankment/bund schemes .. 4
   River training works 10

3. Sangrur and Bhatinda districts
   Ghaggar tract/drainage schemes .. 12

C. *Suggestions*

Priority be given to drainage improvement schemes in areas of Ferozepur, Faridkot, Sangrur and Ludhiana districts affected or threatened by waterlogging. The choes (hill torrents) which cause inundation by flash floods and also destroy valuable agricultural land by sand-casting also need to be controlled.

Rajasthan

A. *Past flood damage data*

The State Government has furnished damage statistics in a general form (and not for any particular year), for the Bharatpur district under Kama-Pahari drain, Banganga and Gambhir rivers and for the Nali bed area of Sriganganagar district under Ghaggar river basin. They have also listed 11 towns abadi areas of which are stated to be affected during the monsoon season, though no damage data have been supplied.

From the flood damage statistics available for the whole State during 1953—78 the average annual damage has been Rs. 1360 lakhs and crop area affected 3.5 lakh ha. The area affected and crop damage have been the maximum during the year 1977. During the year 1979 important towns and villages along the Luni river were affected by unprecedented floods due to heavy rainfall.

B. *State's proposals*

The State Government have identified the following areas where protection measures are urgently required:

1. Kama-Pahari drain areas.
2. Areas of Bharatpur affected by the floods of Gambhir river.
3. Areas affected by Ghaggar river.
4. Towns of Chitturgarh, Udaipur city, Bharatpur city, Nagaur, Makrana, Nawa, Abu Road, Baran (Kota dist.), Ajmer, Khandela and Kot Quasim.

C. *Suggestions*

We generally agree with the need for attention to the areas identified by the State Government as per 'B' above.

Tamil Nadu

The State Government has stated that there are no areas requiring immediate flood protection works. The damage statistics also do not reveal any large recurring flood damage in the State. Thus there are hardly any areas which can be identified by us for urgent attention.

Uttar Pradesh

A. *Past flood damage data*

This is one of the major flood prone State of the country. It accounts for 58 per cent of the total flood damages in the country. The abstract of past damage data is as under:

Period	Annual average	Max in a year
(a) Total area affected lakh ha;		
1950-65	16·80	41·3
1966-70	20·12	34·3
1971-78	30·00	73·4
(b) Total damage lakh Rs.		
1950-65	1229·48	320·2·2
1966-70	1730·16	3081·2
1971-78	4550·81	13394·4
(c) Crop area affected lakh ha . .		
1950-65	7·84	25·7
1966-70	10·42	15·2
1971-78	16·64	39·3
(d) Damage to crop lakh Rs. at constant Prices		
1950-65	1057·80	1893·9
1966-70	1296·28	1147·2
1971-78	3081·19	8975·6

B. *State's proposals*

The Government of Uttar Pradesh has described in a general way the areas falling in different sub-basins which require urgent flood protection. These, in short, are enumerated below:

(i) *The Ganga sub-basin*: Erosion problem exists in Ballia district. Severely flood affected districts are Farrukhabad, Kanpur, Allahabad, Varanasi, Gazipur and Azamgarh town and Mau town in district Azamgarh.

(ii) *The Yamuna sub-basin*: The districts of Aligarh, Mathura and Agra face the problem of drainage congestion and the districts of Saharanpur, Muzaffarnagar, Bulandshahr and Meerut are faced with problem of erosion. Hamirpur town is subjected to erosion by the Yamuna and the Betwa.

(iii) *The Ramganga sub-basin*: No flood problem in the basin.

(iv) *The Gomti sub-basin*: The worst affected districts are Lucknow, Sultanpur, Jaunpur, Hardoi, Faizabad and Rae-Bareli.

(v) *The Ghaghra sub-basin*: The worst flood affected districts are Ballia, Gorakhpur, Basti, Deoria, Azamgarh, Barabanki, Gonda and Bahraich.

(vi) *The Gandak sub-basin*: The most severely affected districts are Deoria and Gorakhpur.

In nutshell, the following 27 districts of Uttar Pradesh need urgent attention:

1. Farrukhabad
2. Aligarh
3. Sultanpur
4. Kanpur
5. Mathura;
6. Jaunpur
7. Allahabad
8. Agra
9. Hardoi
10. Varanasi;
11. Saharanpur
12. Faizabad
13. Gazipur
14. Muzaffarnagar
15. Rae-Bareli
16. Ballia
17. Bulandshahr
18. Gorakhpur
19. Azamgarh
20. Meerut
21. Basti
22. Hamirpur
23. Deoria
24. Lucknow
25. Barabanki
26. Gonda
27. Bahraich:

C. The GFCC has categorised the 54 districts into 3 groups based on frequency of flooding during 10 years.

Based on the analysis made by the GFCC, the 27 districts which, according to the State, require urgent attention are categorised below:

Category-A	
(8 to 10 years frequency out of 10)	Farrikhabad, Ballia, Azamgarh, Mathura, Muzaffarnagar, Meerut, Hardoi, Faizabad, Barabanki, Gonda, Bahraich.
Category-B	
(6 to 7 ytats frequency out of 10)	Kanpur, Allahabad, Varanasi, Gazipur, Aligarh, Agra, Saharanpur, Hamirpur, Jaunpur, Rae-Bareli.
Category-C	
(3 to 5 years frequency out of 10)	Lulknow, Sultanpur, Bulandshar.

सत्यमेव जयते

We suggest priority for the districts under categories A and B above.

West Bengal

A. *Past damage data*

This is one of the major flood affected States in the country. The abstract of past damage data is given below:

Period	Annual average	Max. in a yaer
(a) Total area affected lakh ha		
1950-65	5·39	25·5
1966-70	11·56	21·7
1971-78	19·60	30·0
(b) Total damage lakh Rs. at constant prices		
1950-65	662·20	4434·63
1966-70	1979·01	4108·16
1971-78	1617·40	6829·15
(c) Cropped area affected lakh ha		
1950-65	1·30	6·1
1966·70	4·94	9·5
1971-78	4·66	13·3
(d) Damage to crop lakh ha		
1950-65	560·67	3806·23
1966-70	1252·01	2492·18
1971-78	1108·27	5060·15

B. *State's proposals*

The replies furnished by Government of West Bengal are reproduced below:

> "The State of West Bengal suffers from serious and recurring floods almost every year. The area comprises land varying from high hills on the north to the seas on the south. The problems in different regions are varied in nature and can be divided oin three different categories on the basis of affected zones, viz. (i) North Bengal comprising Darjeeling, Jalpaiguri, West Dinajpur and Cooch-Bihar districts; (ii) Central Bengal comprising Malda, Murshidabad, Nadia, Birbhum; and (iii) South and Southern Bengal comprising 24 Parganas, Hooghly, and Midnapore districts and their coastal regions. In West Bengal excepting a limited number of reservoirs constructed on selected rivers, the common methods used for flood protection are embankments, drainage channels and combination thereof. Urgency of flood protection is determined according to the priorities assigned to the schemes by the Expert Committee and public demand as communicated through the public representatives. The Committees appointed by both the Union Government and State Governments identified areas requiring urgent flood protection works. The Man Singh Committee (1959) was constituted by the State Government to tackle the flood problems of South Bengal. Similarly, North Bengal Flood Enquiry Com-

mittee was set up to examine the areas needing flood protection works. Schemes are prepared in accordance with the recommendations of the Committee in terms of local situation and are implemented through the State's I & W Department. No priority has been prepared by I & W Department of flood affected areas requiring urgent flood protection works."

C. *Suggestions*

GFCC indicated the interse priority of the various districts in the Ganga basin on the basis of the priorities indicated by the West Bengal Government to the working group set up by Ministry of Agriculture & Irrigation in August 1978 to draw up a 5 to 7 years action oriented plan. The districts of North Bengal are subject to ravages of rivers originating in the Himalayas which cause acute problems of flooding, erosion and shifting of river courses. The problem of North Bengal should receive as urgent an attention as any other district of West Bengal. The specific district-wise priorities recommended by the GFCC, based on the intensity of flood damage per ha. are listed below:

Sl. No. Priority No.	Location of area (district-wise whole/part)	Main river/tributary/sub-tributary causing damage	Average loss (Rs. per ha.)
1.	Nadia	Bhagirathi/Jallangi /Churni	3731
2.	Burdwan	Vjoy/Kunur	2328
3.	Murshidabad, Birbhum, Burdwan	Bhagirathi/Mayurakshi	2207
4.	Midnapore	Hoogly/Kasai/Kangsabati/Silabati Darbachatty	1116
5.	Malda, West Dinajpur	Mahananda/Barsoi Branch	881
6.	Midnapore	Rupnarayan/Khals out-fallIng into Rupnarayan in P.S. Aanskura (in Tamluk area)	807
7.	Hoogly Burdwan	Hoogly/Saraswati/Kesarmati-Kunti	764
8.	Midnapore	Hoogly/Haldi	587
9.	24 Parganas Nadia	Bhagirathi/Yamuna	493
10.	24 Parganas	Saptamukhi	324
11.	24 Parganas	Malta/Mograhat	216

XI LAND USE AND REGULATION

1.1. Background

11.1.1. Land and water resources are two vital gifts of Nature to mankind. Their rational utilisation largely helps meeting the primary needs of men on a sustained basis. Being closely related, unscientific and over-utilisation of one has strong influence on the other. In the pursuit to meet their basic needs, faulty land use practised by our increasing population has upset the ecological balance which has led to accelerated soil erosion, loss of the soil mentle and severe reduction in the main absorbing capacity of the eroding land. In consequence, the streams and rivers, which originate from such degraded watersheds, experience flash floods, carry heavy sediment load and aggrade their beds, thereby reducing their bankful capacity. Hence during heavy rains and the resultant peak flows, bank spills occur leading to damage-causing floods. According to the High Level Committee on Floods, 1957. "Flood problems rise not so much due to excessive discharge in rivers as due to excessive sediment load in them."

The common land user is familiar with the muddy water that flows in streams during the monsoon months but he hardly realises the seriousness of the problem of soil erosion, land degradation and its implications in the flood problem. In order to arrest soil erosion and related problems, soil conservation measures have to be taken up in eroding lands under different land-use like crop land, forest land, grazing land etc.

Similarly, water is essential for human welfare. Its availability or scarcity means life or death, affluence or poverty. Although the Indian sub-continent receives, on an average, about 115 cm of rainfall every year, the variations range from less than 15 cm in the arid west to over 500 cm in the humid north-eastern region and most of it is received within a few monsoon months. Hence, it is rational to consider impounding as much of rain water as feasible in the numerous watersheds through proper water-shed programmes. This would help reduce the rate of runoff and sediment discharge, apart from minimising the effects of skewness in the rainfall distribution.

Land users in the flood plains, by and large, suffer from annual floods and sustain most of the flood damage. Although flood plain offers opportunity for the development activities of man, it still remains a part of the river in order to carry its flood-flow during monsoon months, which is many times the rivers' lowest flow. These floods used to cause very little damage when man did not invade the flood plans. With the fast increasing population, the unrestricted occupation of flood plain by land users and developmental works is becoming an important contributing factor to the increase in flood damage.

It is, therefore, considered necessary to regulate the future use of land, lying adjacent to the river through planned development and management. Flood escaping or flood-resisting cropping strategy has to be increasingly adopted in the chronically flood affected flood plains.

11.1.2. *The hydrological cycle and the watershed*

Every point in the earth's land surface drains to some channel point in the neighbourhood. The boundary of such points drainage into a channel or stream delineates the stream's watershed. A river basin or sub-basin is the summation of such numerous watersheds which contribute to the total volume of water flow and sediment charge carried by a given river.

In the global water-balance[1] or hydrological cycle, about $453 \times 10^3 km^3$ of water evaporate annually from the sea. Out of it, nearly $412 \times 10^3 km^3$ of water precipitates over the sea surface. The remaining $41 \times 10^3 km^3$ of water travels in the wind to the atmosphere over land surface where it joins $73 \times 10^3 km^3$ of water evaporated from the land surface. Thus, a total of $114 \times 10^3 km^3$ of water precipitates as rain or snow over land areas. Some of the rain water enters the soil mantle and again an amount of $73 \times 10^3 km^3$ returns to the atmosphere as evaporation from damp soil or transpiration from vegetation. The remainder of $41 \times 10^3 km^3$ runs off to the sea in the form of river and ground water flow from land. This in simple terms is how the global water balance is maintained through the hydrological cycle. The precipitation and evaporation in the hydrological cycle, show distinct seasonal variations. As a result, the river flow also fluctuates according to the season. Spectacular variations in the river flow are experienced under tropical monsoon conditions as is the case in this country. Moderation of such extreme variations is often sought through increasing provisions of storage in natural lakes, artificial reservoirs, soil mantle, and underground aquifers.

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[1] "Water for a starving world", Malin Falkermark & Gunnar Lindh (translated by RG Tanner), West View Press, Boulder, Colorado, 1976

11.1.3. *Basic concepts of a watershed*

In comparison to large basin, the peak flow from a small watershed (catchment) is highly conditioned by the overland rather than the channel flow. A small watershed in the size range of 2000 ha[1] is considered to be sensitive to high intensities of rainfall of short duration and to land use. In larger basins, the effect of channel flow or the basin storage becomes more predominant and its sensitivity to the land factor, unlike in the smaller watershed, is comparatively reduced. In view of this, all studies on experimental watershed hydrology are carried out in small watersheds to evaluate precisely the influence of individual factors on rainfall-runoff relations and sediment discharge. In such studies, the hydrologists consider the runoff as a product in the hydrological cycle which is influenced by 2 major groups of factors, namely (i) climatic factors, and (ii) physiographic factors. There are a number of components in each of these two groups of factors. Hence any quantitative and precise determination of the rainfall-runoff relation from a watershed is an involved exercise. The empirical formulae so far in vogue over-simplify the complex phenomenon through a number of assumptions and do not really take into account all the factors influencing the runoff. Further, most of the formulae use short-period data relating to limited areas and are obviously meant for local application; any projection of such data to other areas may become unreal. There is, thus need for a scientific approach to flood estimation using latest developments in the science of hydrology.

11.2. **Watershed management for flood moderation**

11.2.1 The role of watershed factors amenable to management has been studied by many scientists. The influence of these factors, namely vegetation, topography, soil mantle, underground geology, stream channel and runoff on flood peak reduction, has been known and a sound watershed work plan based on such knowledge is considered useful in mitigating floods through watershed management. Researchers[2] have observed that a dense vegetative canopy provided by a combination of a complete overstorey of mature forest trees and an understorey of herbeceous species, is capable of intercepting more than 12 mm of rain water from each storm, which either evaporates from the foliage or drips down with a time lag to be absorbed by the forest floor. Such dense canopy of vegetation effectively protects the earth's surface from the beating of rain drops, and soil erosion becomes nil or insignificant. The daily rate of evapotranspiration from the vegetative cover ordinarily ranges from 5 to 8 mm and to that extent the storage space for the infiltrated rain water in the soil mantle is continuously made available even under the saturated state. According to available information, the annual evapotranspiration loss from a full vegetative cover rarely accounts for less than 33 per cent of the precipitation in the humid areas and almost all in the lower rainfall regions. With their large leaf area and extensive root systems extracting soil moisture from great depths each season, mature forests record the highest transpiration values. On the other hand, shallow rooted annual grasses extract moisture only from the shallower soil depths, as compared to deep rooted trees. So a saturated soil profile, under good forest cover continues to absorb rain water, although limited to the rate of percolation. As regards the rates of infiltration at which rain water soaks into the soil, the mature forest amongst all natural vegetative covers has the highest rates of infiltration.

Soil depth is a critical factor which limits the storage volume in the profile. Thin soils less than 30 cm in thickness present limited opportunity for watershed management and flood moderation. The soil texture has a profound influence on the profile storage of infiltrated water. For instance, when saturated a 30 cm soil layer of fine sand has a maximum water holding capacity of about 12 mm, while the capacity of silty and clayey soils is of the order of 62 mm and 112 mm respectively. Rain water in excess of the absorption capacity of a watershed would appear as overland flow which when interrupted by a defined channel course or stream, becomes concentrated channel flow. Under upstream conditions, the small channel flow is intermittent and occurs mostly during sustained rainfall. If stored behind a dam, such water flow of head water streams can profitably be utilised by local people. In downstream conditions, when head water streams join to form rivers with much larger drainage area the river flow is likely to become continuous due to combined effects from surface, sub-surface and underground flow. The seeps and springs are also reckoned features of sub-surface and underground flow. Such underground flows are of low velocities and extend over months after the rains. With a well-managed watershed, spring flows can become continuous throughout the year. Indeed, frequent reports on the drying of numerous springs in the hills and Himalayan mountains are clear warnings of their poor watershed coditions. It is recognised that well managed watersheds coupled with structural measures in the basin/sub-basin will go a long way in moderating low to medium floods and silt charge.

11.2.2. *Salt affected land*

Over 2.5 million hectares of salt affected land with alkali soils, occur in the chronically flood prone States of Punjab, Haryana and Uttar Pradesh in the Indo-Gangetic plains. These problematic soils have extremely low or nil infiltration rates and are associated with high water table conditions. Such situations contribute most to overland runoff and local problem of drainage congestion. Improved technology is available today for the reclamation of salt affected and alkali soils. A 3-phase drainage and storage system, namely (a) stocking the maximum possible rain water in the rice fields, (b) storing excess runoff from rice fields in dug farm ponds, and (c) holding the remainder of the runoff in a community reservoir, offers opportunity to be successful in utilising most of the rain water for high-yielding rice production and reclamation of such problematic land with soil amendment. In appreciation, we recommend that large scale reclamation of alkali soils in the flood prone Indo-Gangetic States of Punjab, Haryana and Uttar Pradesh, may be taken up and 3-phase drainage system adopted, for minimising the overland flow and drainage congestion.

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[1] The Committee on Runoff of the American Geophysical Union (1957)

[2] Food and Agriculture Organisation of U.N Occasional Paper No. 13 : Rome, 1962.

11.2.3 *Operatoinal watershed data*

Information is available from the reservoir survey in some of the river valley projects where soil conservation and watershed management programmes have been taken up during the previous Plans. The main objective was to prolong the life of reservoirs threatened by high rate of siltation. Where critical areas have been covered sufficiently by land treatment or soil conservation measures along with structural practices, the rate of sedimentation in the reservoirs has been significantly reduced. For instance, in the case of Machkund catchment, the annual silt rate for design purposes was assumed at 3.4.ha. m/100 sq. km. After extensive soil conservation measures had been undertaken in the catchement, the annual sediment rate is reported to be 2.36 ha. m/100 sq.[1] The evaluation report, 1971-72, for Kundah Project (Tamil Nadu) has reported a reduction of silt by 72 per cent in case of Silahalla stream, 68 per cent in case of Klinjadahalla and 37 per cent in case of Bhowani river, following soil conservation. Simililarly after watershed and soil conservation measures were under taken in Damodar Valley[2], a reducation in annual rate of siltation of about 15 per cent has been reported in the case of Maithon reservoir between the years 1963 to 1973 and of about 25 per cent in case of Panchet reservoir between 1962 to 1974. While drawing the above trends, however, the effects of annual settlement and shrinkage of sediments as also the sand stowing activities have not been taken into account due to lack of quanitative information on them. Also, integrated soil conservation and watershed management works were taken up during 1955-56 in the upper Sewani sub-catch-area of 93.24 km^2, about 40 per cent of the total ment in the Damodar Valley, which has a total area of 93.24 km^2, about 40 per cent of the total ment by 1961. As compared to the pre-treatment rate of annual sediment production of 904 cu. m/km^2 the post-treatment rate of annual sediment production was reduced to 381 cu. m/km^2. Reservoir surveys have been carried out in the basins of Bhakra and Ramganga projects, where soil conservation and watershed management works have been carried out extensively. According to the survey data quoted below, the rate of sediment discharge from the contributing catchments has been reduced significantly as a result of the soil conservation and watershed management works.

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TABLE 11.1

*Effect of soil conservation measures on sediment discharge in Bhakra and Ramganga basins**

Reservoir	Catchment area ('000 ha).			Sediment yield (ha. m/100 km^2)			
	critical	created	% of critical area treated	assumed	original	observed	% reduction
Bhakra	557	126	23	4.3	6.9	5.2	25
Ramganga	104	42	40	4.3	22.0	16.8	23

**Source* : Tech. Bull, Soil & Water Conservation in the catchments of river valley projects, Soil Cons. Dtc. CWC (G.P. Gupta)

11.2.4 **Effect** of land treatment and head water structure in moderating flood peak has been studied extensively in the United States of America. In the Mississippi basin States like Arkansas, Okhlahoma and Texas, 367 head water control structures were constructed to provide around 0.35 lakh hectare metres (2.85 lakh acre ft) of detention storage. These could handle in detaining and gradually releasing 0.66 lakh hectare metres (5.35 lakh acre ft) of flood water[3]. Thus the structures not only lowered the peak but reduced the volume and delayed the flow. Reputed flood engeineers in USA held the following view[1]:

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[1] G. P. Gupta I/c Soil Conservation Directorate, Central Water Commission, An appraisal of sedimentation problem in the country and measure to combat it : CBI&P Publication No. 126, 1977, pp. 1-9.

[2] B. N. Murthy, Director, Damodar Valley Corporation, Maithon Dam : Reservoir sedimentation, life and remedial measure : CBI&P Publication No. 126; 1977, pp. 123- 134.

[3] Performance of Flood Prevention Works: Howard Matson; Transactions, ASAR, Vol. IX (2): pp. 196-97: 1966.

> "The location of small reservoirs, as an average, produces flood reduction of approximately 35 per cent on head water tributaries which drain areas from 50 to 125 sq miles. The magnitude of this reduction becomes progressively less as the flood waves proceed to the lower portions of the basin. Thus the estimated flood reduction on the main stem of the Meramec (River) is approximately 20 per cent."

The US Department of Agriculture (Agricultural Research Service) has undertaken small watershed programme for flood prevention[2]. In one case, the programme involved construction of 25 small flood detention reservoirs on upstream tributaries in a 622 sq km watershed of the Washita river. Okhlahoma USA. On completion, these structures effected reduction in flood peak of a major flood by 50 per cent.

11.2.5. These results exhibit the usefulness of land treatment methods in moderating flood and reducing sediment discharge from watershed, although generally their effect on large damage producing floods is not considered significant. Also, it is known that reservoirs are time-honoured long-term measures for flood moderation and to prolong their life, soil conservation measures have been universally adopted. We, however, observe that there is a paucity of adequate and refined data on stream flow and silt discharge as influenced by soil conservation and watershed management treatment from large scale experimental and representative watersheds for our tropical monsoon conditions. Hence it is recommended that hydrological studies in experimental watersheds should be intensified by the agricultural and forestry research organisations in the country. Similarly studies should be undertaken in the representative watersheds by premier engineering research bodies like the National Institute of Hydrology and Engineering Research Institutes.

11. 3. Soil conservation in crop land and watershed management during the plans

11.3.1. The First Five Year Plan took a serious view of the widespread problem of soil erosion when for the first time, a countrywide soil conservation programme for execution in the crop and forest land was enunciated. The package of measures/practices envisaged:

(i) regulation of land use according to its capability and retirement of land in the highly erodible areas to forest and grass; restrictions on or closure of grazing i badly eroded forests or grazing land an settlement of shifting cultivators to permanent cultivation;

(ii) afforestation and preservation of forest by scientific management;

(iii) improvement of land use practices o farm lands; contour ploughing and contour planting, strip cropping on slopin land, proper crop rotation; fertilisers an manures; care of fallow and other uncultivated lands; and

(iv) engineering measures; bunds, terraces ponds or small reservoirs, check dams channels for drainage of surplus water gully plugging, etc.

For proper implementation of the programme the Plan suggested setting up of high-power Soi Conservation and Land Use Boards at the Centre as well as at the State level. Besides, suitabl legislation was also suggested for smooth execution of the planned programmes by the State Governments.

11.3.2. The First Plan also emphasised the implementation of soil conservation works in the catchment areas of every river valley project. The view has been held that proper soil conservation measures in the catchment areas would be as essential as the construction of dams for development of water resources. It has been stated that high silt load in the inflow to the reservoir would increase the cost of operation, impair efficiency and reduce the life of reservoirs. Once silted there may be no better dam site easily available as a substitute. Hence it has been stressed that measures for erosion control and improvement of land use should form a part of work in every river valley project.

11.3.3. During the Third Plan, soil conservation measures for silt reduction in the inflow into the reservoirs were taken up in 13 selected river valley projects under a centrally sponsored programme. During the Fifth Plan, the programme was extended to cover 30 river valley projects.

According to the information given in the Sixth Plan Working Group Report on Soil Conservation of the Union Department of Agriculture, at the end of the fourth year of the Fifth Plan it may be taken that about 22 million hectares of land area under different land use would have been covered with soil conservation measures at a total cost of about Rs. 511 crores. According to an estimate, about 150 million hectares of land have been seriously affected by wind and water erosion which need urgent soil conservation treatment. As against this national target, only about 22 million hectares have so far been covered. It means hardly a little over 14 per cent of the problem area has been treated during last 27 years. Much more needs to be done to treat the remaining 86 per cent of the critical area.

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[1] Zingg, 1946, quoted from "The Flood Control Controversy" by Leepoled and Maddock; The Conservation Foundation; Ronald Press Co; New York, 1954.

[2] Water for Peace, Vol. 2, pp. 641—45; Washington DC; 1967.

11.3.4. From flood mitigation point of view, provision of small and large reservoirs along the course of rivers and their tributaries has been universally accepted as an important measure for a long-term solution. As stated earlier, the centrally sponsored river valley projects have been taken up since the Third Plan; the current programme covers 30 river valley projects. A statement indicating the progress of this work is placed at Annexure 11.1. It is observed that the total catchment area of the 30 projects is about 77.65 million hectares of which the critical area has been estimated at 23.6 million hactares. Only about 1.26 million hectares have so far been treated up to the end of 1977-78 at a cost of Rs. 701 million. Here also much more has to be done to treat the remaining critical areas.

11.3.5. The National Commission on Agriculture has strongly recommended intensification of soil conservation and watershed management works in the catchment of river valley projects and emphasised that within 5 years, all the watershed management plans should be completed. Other bodies like the Central Flood Control Board, the High Level Committee, 1964 and the Irrigation Commission, 1972 etc., have also recommended soil conservation and watershed management measures. The Irrigation Commission has, in fact, emphasised execution of these measures in the critical areas of all the river valley catchments within 20 years. While developing the strategy, policies and programme for the five year period, 1978-79 to 1982-83, the Working Group on Flood Control, Union Department of Irrigation, *inter alia*, has recommended that (i) all storage reservoir projects in the catchments of flood prone rivers should be given priority for construction during next 5—7 years and (ii) soil conservation programmes would be complementary to the engineering programme of flood control and should be taken up simultaneously but the economic justification of this programme may come largely from their other inherent benefits.

Amongst other recent developments in the flood sector, one needs to mention the integrated action plan for flood control in the Indo-Gangetic basin, prepared by a high level working group of engineers, agronomists, foresters, economists and administrators constituted by the Government of India, in the wake of the worst flood experienced in the country during 1978. Identifying the most flood prone basins and sub-basins, the working group recommended an integrated action plan for engineering soil conservation and watershed management works. In pursuance of their recommendations the Planning Commission have already allocated Rs. 90 crores for execution of soil conservation/afforestation works during the Sixth Plan.

It is further recommended that such land treatment measures may be taken up on priority basis in the catchments of chronically flood prone rivers in the country, specially of those which originate from the Himalayas, Siwalik foothills and hilly tracts of Central India. This is, no doubt, a massive task. People's large scale participation in the programme will go a long way in achieving the target. As these works are to be executed generally in difficult terrain, it would warrant adequate strengthening of the programme implementing agencies. In view of the foregoing we recommend that (i) integrated action plan on soil conservation and watershed management for the catchments of the most flood prone rivers in the country should be developed, implemented on area saturation basis and maintained, (ii) commensurate with the task, the programme implementation agencies at the Centre and State level should be adequately strengthened with trained staff and facilities to execute works in difficult terrains, and (iii) massive people's participation in the programme should be organised to complete the task at least during the current century.

11.4. Forest land and the flood problem

11.4.1 Whenever devastating floods occur, the casual factors are sought in the vanishing forest cover. It is known that a well managed forest cover has profound influence on watershed hydrology. The high rain absorbing capacity of forest soil contributes most in minimising the overland flow. A good forest cover protects the ground from soil erosion and thereby reduces the rate of sediment discharge. Above all, a well managed forest watershed provides a year-round stable flow in the springs and streams. These are only a few benefits which are also relevant to the flood problem. There are, however, many other benefits concerning environmental and ecological aspects which flow from forest wealth. Notwithstanding these considerations, the forest land continues to be most exploited for meeting the needs of our growing population and development programmes.

11.4.2. Compared to some of the advanced countries, the area under forest in this country is low. Recognising the extensive deforestation made during the Second World War and in the large areas of Zamindari forests, the Government of India enunciated the National Forest Policy in 1952. It prescribed that the country as a whole should have at least 33 per cent of the land area under forest. Also as an insurance against denudation of soil, a much larger per cent of land, about 60 per cent, should be under forest cover, specially in the Himalayas, the Deccan and other mountainous areas subject to severe erosion. By and large most of our forest land has been relegated to hills and mountain tracts due to expansion of cultivation and human settlements in the plains. Every river in the country rises in the hills and the condition of the forest land occupying the upper catchments will predominantly influence the fury of the annual floods and hence would need more attention.

11.4.3. According to the statistics received from Forest Department of the States, about 75 million hectares of land are under forest. This means only about 22.8 per cent of the total geographical area in the country is under forest as against the national target of 33 per cent. Of the 75 million hectares, 51 per cent is under reserve forests, 32 per cent under protected forests, and the remaining 17 per cent is treated as unclassed forests. The 49 per cent of protected and unclassed forest land, outside the reserve forest, is riddled with people's rights, over-exploited and forms the most vulnerable area. The civil and private owned forests, though small, are poorly managed unlike reserve forests. These are, indeed, the sore spots in the upper catchments, which contribute to high sediment discharge. The cover density of the forest land is another factor exercising profound influence on the hydrological behaviour of the watersheds. Extensive areas recorded as forest land are practically devoid of adequate cover. No systematic information is available on the uptodate cover condition for the forest areas nor any hydrologic grouping of the forest land has been attempted. In planning any extensive programme of afforestation, at least for the critical areas in the upper catchments of the flood prone rivers, one must obtain dependable information on these aspects.

11.4.4. In view of the role that forests play in flood mitigation, we recommend that a systematic inventory of the forest cover complex and the hydrologic grouping of the forest land should be taken up. This will help planning of meaningful watershed management programmes. We therefore recommend that (i) uptodate mapping of land uses and cover complexes occurring in the upper catchments of chronically flood-prone rivers should be completed expeditiously, (ii) the critical areas are delineated on the basis of this map to help developing for them economically viable action plan on watershed management, and (iii) besides undertaking a massive programme of afforestation in the catchments to provide vegetative cover on marginal and waste lands, efforts should be made to declare more forest areas as reserve forests for better management.

11.5. Special problems of the catchments

11.5.1. The evil effects of deforestation and degradation of land on soil erosion, watershed hydrology and flood have been dealt with earlier. There are 6 major factors which contribute to high rates of run off and sediment discharge from the upper catchments. These are (i) shifting cultivation, (ii) grazing, (iii) people's right and privileges, (iv) forest fires, (v) surface mining, and (vi) land slides and slips. These are very serious in the Himalayan upper catchments which feed the most flood prone rivers of the Indo-Gangetic and Brahmaputra river systems.

11.5.2. *Shifting cultivation*

This is a primitive practice of raising crops, and is generally practised in the mountainous upper catchments by the tribal people. This is a slash and burn practice of crop production locally known as 'jhum' in Assam, Tripura and other north eastern hill region and 'podu' in Orissa and Andhra. No dependable statistics are available on the magnitude of this problem. However, according to a countrywide study[1] made in 1956, about 5.42 lakh hectares in the mountainous catchments are under shifting cultivation, supporting some 5.29 lakh tribal households and nearly 26.44 lakh tribal people. In the north eastern region[2], the area under shifting cultivation at a given time was about 4.55 lakh ha., however the total area affected by this evil practices some time or the other would be about 2.7 million ha.

11.5.3. Within a short period during which the problem has been studied, the ICAR Research Complex, Shillong, has advocated a topo-sequence in land use in the eastern hills. According to this suggestion, the top one-third of the mountain slope should be under forests, the middle one-third devoted to horti-pastoral system with half moon terracing for horticultural plantings, and the lower one-third slope adjoining the valley brought under agriculture with bench terracing. For agricultural land the following cropping patterns have also been proposed for rainfed 'jhum' land in Tripura which has already been taken up for popularisation in the State.

TABLE—11.2

Rotation	Crop	From — To	Yield (Kg/ha)	Varieties
(a) 2 crop rotation	Rice	April 15—July 15	2000	CRM 13—3241 AR11—43
	Sweet potato	July 30—Nov. 30	20000	Cross 4
(b) 3 crop rotation	Rice	April 15—July 15	2000	As above
	Rice	July 15—Sept. 30	1500	,,
	Cowpea	Oct. 7—Jan. 7	800	Assam Valley

[1] Review Series No. 24. Shifting cultivation practices in Inida by D.C. Kaith, Indian Council of Agricultural Research 1958.

[2] Report of the National Commission on Agriculture, 1976, Part IX, Forestry, p. 148.

Citrus plantations are popular in this hilly terrain but they are being abandoned due to 'citrus decline'. Rejuvenation of such orchards along with marketing and processing facilities may build up the citrus-economy for the tribals. This is considered the best step to encourage 'jhumias' to gainfully take to settled horticulture within a short period as a major enterprise. The ICAR complex has further found that the high-density planting of pineapple, so popular in the north-eastern hills, on 30 per cent slopes and above, with legumes as companion, crops, would be profitable while minimising sediment discharge and runoff from hill slopes. Above all, irrigated wetland rice terraces on the lower slopes around the valley are getting increasingly popular. In the top one-third of the slopes mulberry and oak plantations for sericulture would be another choice for boosting up tribal economy. A pilot project has also been taken up to introduce innovative land-use patterns in meeting the challenge of shifting cultivation and degraded watersheds. From the point of view of flood problem also, we feel that the current efforts of the North-Eastern Council and the member States and Union Territories of the region need to be intensified. In this direction it is recommended that the concept of growth centres or urban centres for about 10,000 population in the fertile valleys should be developed on pilot scale with all urban amenities and agro-industry co-operatives for processing and marketing of the hill produce. This would promote migration of tribal people from the hill slope to the valley for permanent settlement.

11.5.4. We have already stated that overgrazing degrades the watershed. Sediment discharge and overland flow volume increases fast from such degraded catchments. The situation is grave as our livestock population is very high. In 1956, this number was 302 million which rose to 355 million in 1972. At this rate, today's population may be projected to around 400 million. As there are no defined pasture or grassland, the vast livestock population grazes in the ill-managed village common land, community wastelands or in neighbourhood forests, if any. By and large, the protected and unclassed forests provide most of the grazing land. Seriousness of the grazing problem in some of the Indo-Gangetic States is brought out from the following figures:

TABLE 11.3

Livestock population and forest grazing in some of the flood prone Indo-Gangetic basin States[1]

State	Total live-stock ('000 No.)	Number grazing in forest ('000 No.)	Percent grazing in forest (%)	Total forest area (67-68) ('000 ha)	Forest area	
					Closed to grazing ('000 ha)	Opened to grazing ('000 ha)
Jammu & Kashmir	4,285	582	13.6	2,108	228	1,880
Himachal Pradesh	4,703	4,005	85.1	2,158	240	1,918
Punjab	9,295	299	3.2	197	119	78
Uttar Pradesh	49,099	2,005	4.1	4,882	721	4,161
Bihar	27,946	8,530	30.5	3,059	475	2,584

The Himalayan catchments of Himachal Pradesh are heavily grazed by 85.1 per cent of its total livestock population of 4.7 million. Except in case of Punjab, where forest area is limited, most of the forest area is heavily grazed, as in Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh and Bihar. In recognition of the implications of overgrazing of the upper catchments, we feel that urgent action should be taken to rationalise forest grazing.

11.5.5. Grazing rights, privileges, and concessions for forest produce, minor timber etc. are numerous and vary from State to State. Forest regulations admit such rights. Tribal people in States have their free rights to grazing and extracting minor forest produce. There is also a specified class of people who have rights to collect some forest produce for their household use and agriculture under a system known as 'Forest-Nistar'. According to 'Forest Nistar' the villager is allowed (a) to freely collect timber of some declared species for farm implements, building of houses, cattlesheds, etc. fuel as also bamboos and fodder grass, and (b) extraction of minor minerals, edible fruits, roots, gums, honey etc. There is also provision for village artisans in the name of 'Occupational Nistar'. These practices contribute heavily to the degradation of watersheds and we endorse the steps suggested by the National Commission on Agriculture (NCA) for regulation of 'Nistar' land and advocate that all protected and unclassed forests burdened with 'Forest Nistar' rights should gradually be declared reserve forest.

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[1] Report of the National Commission on Agriculture, Part IX, Forestry, pp. 213.

11.5.6. *Forest fire*

Forest Departments have a practice of regulated fire in more moist regions for encouraging natural regeneration of teak (*Tectona grandis*), 'sal' (*Shorea robusta*), deodar (*Cedrus deodars*), etc. This is mostly done to check the growth of evergreen tree, shrubs and woods, reduce depth of leaf litter and create a conducive site for the germination and establishment of seedlings. In 'chir' pine (*Pinus roxburghii*) forests controlled fire is a regular practice to ward off large scale fire due to accident or wanton mischief in hot summer months. However, the unregulated wild fires are fraught with danger for deteriorating watershed conditions. Such incidence are numerous. They damage the soil and rob the forest of its productive and protective capacity; hence the normal hydrological functioning of the forest watershed gets upset. The subject has been well covered in the report of the NCA and we agree with their recommendations on the control of forest fires. We recommend that special attention may be paid to the Himalayan coniferous zone and the deciduous forest region of Central India.

11.5.7. *Surface mining*

This practice is widespread in the country. Such mines are also located in the mountainous or hilly waste lands, which constitute a large portion of the upper catchments of rivers. We are aware that minerals, building materials etc. have to be quarried for industry, agriculture, construction purposes etc. At the same time there arises a responsibility on the part of the mine owner to rehabilitate the mine-spoils so that the mine area rehabilitates under an adequate vegetative cover and contributes least amount of sediment to the stream flow.

There is no data available on sediment discharge from mined areas. An estimate of the mined areas currently under lease has however been attempted for 9 selected States, covering flood-ravaged northern plains and east coast. The data have been extracted from the Directory of Mines and Mining Leases Vol. I (Part I and Part II—up to 1970) and Vol. II (1971—1974) published by the Controller, Indian Bureau of Mines, Nagpur, and are given in table below:

TABLE 11.4

Mining area under lease in selected States up to 1974

States	Areas under lease (in hectares)
(1)	(2)
Assam	3,789
Meghalaya	2,372
Himachal Pradesh	469
Jammu and Kashmir	886
Madhya Pradesh	51,889
Orissa	1,17,873
Bihar	1,40,662
West Bengal	15,125
Uttar Pradesh	7,649
Total of 9 States	3,40,714

In these 9 States, a total area of about 3.41 lakh ha. is under the current lease of mining which does not appear to be complete nor include the old mine aeras. Still, a sizeable area of mine spoils appear to be evident. They become the worst sediment-producing spots in the watershed. One may size up the problem by the ghastly sights of the surface mining spoils on the Mussoorie hills and in the Chhotanagpur and Orissa plateau. We therefore feel that while promoting exploitation of mineral wealth for the country's progress, we should take immediate steps to stabilise the extensive mine spoil areas to prevent any environmental degradation and high sediment discharge from the watershed. In the interest of maintaining healthy watershed conditions we recommend that by a suitable clause in the lease deeds it should be made obligatory on the lessee to stabilise the mine spoils through establishment of a suitable vegetative cover. In case of default, the State Forest Department should have the powers to undertake afforestation works for the stabilisation of the mine spoils and recover the cost from the lessee.

11.5.8. *Land slides*

The mountainous upper catchments experience land slides which contribute substantial amount of silt to stream flow. Compared to the mountains in the Deccan plateau or central India, the Himalayan ranges experience serious land slides. No systematic or reliable data are available on the extent of the problem and the amount of silt contributed from this source. With the increasing activities of road construction in the Himalayan region, road engineers annually face the land silde problems for clearing the debris and keeping the roads open. So some idea about the volume of debris contributed by the land slides along the Himalayan roads may furnish a first approximation of the silt estimates contributed from this source, though numerous landslides occurring in inaccessible areas will remain beyond any possible estimation. Under the circumstances an effort has been made to give a partial view of the serious problem of land slide infesting the entire stretch of the upper catchments of our most floodprone rivers of the Indo-Gangetic and the Brahmaputra river systems. Due to its characteristic geological formations and being in the seismic region, the problem in the upper catchments is, however, difficult of any permanent solution.

11.5.9. For obtaining a quantitative estimate of the contribution of silt in stream flow, the Central Road Research Institute, has furnished a first approximation of the debris-estimate by analysing data concerning the frequency and magnitude of landslides that have occurred in recent years in a vulnerable section of the hill road. For the purpose, a particular stretch of 70 km. of road in Himalayan area has been chosen. This is a stretch of National Highway which passes through 'Siwalik' clay shales and is rated as highly prone to land slides.

The Fig. 11.1 gives the actual distribution of frequency and magnitude of land slides. Out of 16 landslide spots recorded, 2 are very large in size, the affected areas being 1,20,000 square metres and 30,000 square metres respectively. The first slide has grown due to its instability during last 20 years from a medium to a large one over years. During the last few years it is showing the trend of slow stabilisation. The second slide has started a couple of years back. Due to site conditions it has the tendency of increase in activity to grow in subsequent few years unless extensive remedial measures are adopted. The total lengths covered by the slides in the 70 km. study section of the road is 1,200 metres (1.7 per cent of road length). The area affected is about 2,00,000 square metres. The total road length in the Himalayan areas being in the order of some 15,000 km. the silt charge contributed to the Indo-Gangetic river system from land slides along roads may be enormous. An idea of the problem may be obtained from the following order of the quantities of land slide debris annually cleared by the Border Road Organisation alone in some of the sections of the Himalayan region.

TABLE 11.5

*Land slide debris annually cleared by the Border Roads Organisation in the Himalayan region**

Himalayan Region	Road Section	Year	Quantity of land slide debris cleared in cubic metres	
			Total M^3	Average per km. road M^3
Western Region	Jammu–Srinagar Road, km. 90 to km. 189	77–78	72,436	724.36
Central Region	Tanakpur–Tawaghat Road, km. 10 to km. 120	78–79	45,232	411.20
Eastern Region	Sikkim Highway NH 31–A, km. 07 to km. 92	78–79	58,701	690.60

**Source*: Directorate General, Border Roads, DHQ, New Delhi.

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These figures indicate the huge amount of land slide debris which is being cleared annually by the Border Road Organisation alone along the Himalayan hill roads. Being considered as one of the sources of sediment of the Himalayan rivers, urgent attention needs to be paid for stabilising as far as feasible, the land slides and their debris in the Himalayan catchments. As an important steps in this direction, we recommend that (i) the concerned Departments should stabilise road cuts and fills to minimise land slides; while clearing the roads loose debris of land slides should also be established as far as possible; (ii) suitable arrangements should be made to monitor the land slide menace and its contribution to silt charge in the stream flow of the Himalayan rivers.

11.6. Land use and regulation

11.6.1. Legal provision has been sought from early years to regulate land use. From the flood angle, one needs to examine the adequacy of these provisions before any additional measure could be thought of. We have examined the legal provisions mostly for the 2 major land uses, namely, the forest land and crop land, which together account for more than 66 per cent of the country's land area. According to 1972-73 statistics the forest land occupies about 22 per cent of land area. Adequate provisions were made for preservation and management of the country's forest wealth in the National Forest Policy announced in 1952.

11.6.2. *National Forest Policy* 1952

Prior to 1952, forest legislation existed in the Indian Forest Act, 1927, and Madras Forest Act 1882. After Independence it was considered necessary to revise the Forest Act, 1927, and announce the National Forest Policy, 1952, in order to be relevant to the post-war reconstruction projects, river valley projects and industrial and communication developments. Vital needs were enunciated to form the base of the National Forest Policy and they include,

- appropriate management of forest resources for providing maximum goods and services to the people and facilitating economic progress of the country;

- control of denudation and erosion in the mountainous regions and watersheds of the rivers on which depend the perennial water supply, land fertility, and viability of irrigation dams and reservoirs; control of erosion on treeless banks of great rivers, western desert, wastelands and sea shore;
- maximisation of forest productivity to meet people's needs;
- provision to meet the needs of rural and tribal people relating to small timber, minor forest produce, fuel wood and grazing;
- providing forest amenities in urban areas and recreational and tourist opportunities in the forests without detriment; and
- utilisation of culturable waste, canal banks, strips along roads and railways for tree crops for aesthetic, productive and protective purposes.

These were laudable objectives which adequately cover the core elements for good watershed management. Keeping in view the above needs, the policy document prescribed 60 per cent of land in mountainous and hilly areas and 33 per cent forest cover, on the whole, for the country.

Forests remain a State subject, and States have therefore made their forest laws to suit their conditions. People's rights and privileges on forest land have constrained proper management of protected and unclassed forests. The grazing principles and extension of trees to vacant land remain largely unfulfilled. The target of obtaining at least 60 per cent of land under forest as a check on erosion in the mountainous regions has not also been fulfilled. We endorse the recommendations made by the NCA relating to the forest land and emphasize the developmental approach on priority basis for the upper catchments of the flood-prone rivers. Recognising the difficulty experienced in establishing plantations on the highly eroded hill slopes of the Himalayan region, we recommend that under the existing legal provisions, large-scale closure to grazing in such areas should be enforced and measures to develop them as low or high altitude grass land should be taken up.

11.6.3. *Land use regulation in crop land*

In 1955 a model bill for soil conservation was circulated by the Government of India to all States and territories for adoption. The main objective of the Bill were to provide for preparation and execution of land-improvement schemes including schemes for conservation and improvement of soil resources, prevention or mitigation of soil erosion, protection of land against damage by flood drought and reclamation of waste land in the States. Accordingly, most of the States have enacted soil-conservation legislation, though with different titles and provisions, in conformity with local needs, existing legislation etc. By and large, the central theme of the model Bill has been kept in view, namely to regulate, restrict or prohibit in a notified area the clearing or breaking up of land for cultivation, faulty cultivation, quarrying of stone or burning of lime, felling of trees, setting fire to trees, herding or pasturing, erection of buildings etc. For implementing the provisions of the Act, the State Governments set up State Soil Conservation and Land Improvement Boards, and District Committees. At the Centre, a high-power Central Soil Conservation Board was set up in 1953 to co-ordinate State activities, and to undertake research, training and demonstration in soil conservation. It may be worth mentioning that prior to the above-mentioned legislative measures, some of the States also had in force important Acts for land-use regulation; for instance, the Bombay Land Improvement Act, 1942, Orissa Agricultural Act, 1951, Preservation of Cho Act, 1901 of Punjab, Travancore Cochin Land Development Act, 1950, and so on. We have examined the prevailing legislation for soil conservation and land use regulation in some of the most flood prone States and consider the existing legal measures adequate for enforcing appropriate land use, provided there is a will to enforce them.

11.6.4. *Flood-plain zoning*

The subject of land-use regulation in flood plains drew the attention of the Central Flood Control Board. In 1957 the Board observed that the quantum of flood damage was bound to increase due to indiscriminate development and settlements. Hence it accepted, in principle, the enactment of legislation for demarcating flood zones, and preventing indiscriminate development of flood plains, occupation or cultivation of lands of rivers and drainage channels. The Board, however, suggested that the erstwhile Ministry of Irrigation and Power should examine the constitutional provisions on the subject before commending it to the States. Accordingly the matter was examined. The conclusion was that flood plain zoning as such would not require any fresh legislation and the areas affected by different intensities of flood could be demarcated after collection of data and surveys. Also, the view was held that under the existing laws in force, action could be taken against any person for encroachment interferring with the flow of water. So the States were advised to initiate the demarcation of flood zones. Subsequently the Ministers' Committee on Flood Control, 1964, considered the matter and observed that no special legislation was necessary for the purpose which could be attained by determined administrative action. The Ministers' Committee therefore recommended (i) preparation of basin maps showing flood zones for wide circulation and people's awareness of the flood risk and (ii) issue of administrative orders restricting the occupancy of flood zones. The Ministers' Committee on Floods and Flood Relief, 1972 observed no progress in the matter and re-emphasized the earlier recommendation made by the Ministers' Committee on Flood Control, 1964. The Indian Law Institute which also examined the case viewed that under constitutional provision, flood plain zoning falls within the competence of the State Governments and offers little scope for Central legislation. However, the Central Government could prepare and circulate a model bill giving guidelines to the States. The Ministers' Committee on Floods and Flood Relief (1972) citing the success of Andhra Pradesh Government in controlling encroachments into rivers and drainage channels, by means of the River Conservancy Act, recommended review of the existing legislations to ascertain their adequacy for flood plain zoning. These recommendations were considered by the Irrigation and Power Ministers' Conference in July 1972, and the need of suitable legislation for flood plain zoning was stressed. Accordingly, a draft model bill on flood plain zoning was prepared and circulated to States in July 1975 for eliciting their views on (a) type of organisation needed for enforcement of the provisions made in the bill, (b) the nature of restrictions to be imposed, and (c) payment of compensation for areas coming under the purview of the bill.

11.6.5. *The Draft Bill*

The Bill provides for the zoning of flood plains of rivers. Flood plain has been defined to include "water channel, flood channel and that area of nearby low land susceptible to flood by inundation". Where the State Government considers it necessary or expedient to do so, it may declare by gazette notification that flood plains zoning shall be made for the flood prone river so chosen. The Flood Plain Zoning Authority appointed by the State Government in relation to a river, shall carry out required surveys in the flood plains of the notified river and determine the extent of the flood plains. On the basis of the survey, the said Authority shall establish flood plains zones and delineate the areas which are subject to flooding including classification of land with reference to relative risks of flood plain use, with the intention to safeguard health, safety and property of the general public. The areas so delineated by the Authority and approved by the State Government shall be deemed to be the flood plain and the limits, where necessary, shall be marked either by boundary stones or other suitable marks. Under Section 12, powers exist to prohibit activities, obstructions etc. Where the State Government is satisfied that in the interest of public health, safety of property or reducing inconvenience to the general public, it is necessary to prohibit or restrict activities in the flood plain, the Government may, by notification of such areas enforce the required prohibition or restriction of such activities. No person thereafter shall undertake any activity within the prohibited area wihout permission of the Flood Plain Zoning Authority; penalties have been provided for any violation. Section 24 also empowers the Authority to direct, if considered necessary, any owner or occupier of the land to do any act or to remove any unauthorised obstruction within a specified time. In case the land owner or occupier fails to comply with the directions, the Authority may cause the act to be performed or remove the obstruction and recover the cost as arrears of land revenue from the concerned persons.

To ascertain the present status, we sought the views of the States and the Union Department of irrigation. Out of 18 State replies, four States, and one Union Territory, *viz.*, Gujarat, Jammu & Kashmir, Punjab, Maharashtra and Arunachal Pradesh did not consider the proposed enactment necessary. Kerala has declined to take any action as it apprehends difficulty in enforcing the regulatory provisions on account of high pressure of population and limited availability of land. West Bengal has favoured flood plain zoning provided the State is not asked to bear the cost of implementation which has to be enforced through an elaborate organisational infrastructure. This State, at the same time, holds the view that such land use regulation or prohibition can as well be enforced with the existing legislative measures provided there is the will to do it. Uttar Pradesh, while supporting the draft Bill, has expressed its inability to take any action in the absence of (a) required hydrological data relevant to different flood frequencies, (b) suitable contour maps and above all, (c) an appropriate organisation to implement the programme. Manipur has passed an Act. The draft Bill is still under consideration in the 6 States of Assam, Andhra Pradesh, Bihar, Madhya Pradesh, Tamil Nadu and Orissa. The 3 States of Haryana, Karnataka and Rajasthan have supported the Bill and suggested its implementation by a proposed Flood Plain Zoning Authority under the officers of the Revenue Department like the Deputy Commissioner or the District Magistrate, who are competent to enforce land-use regulations. Haryana has also suggested the setting up of Central Flood Zoning Authority for inter-state border areas posing problem relating to rivers or drainage channels. Delhi has supported the Bill for imposing restrictions on structures like buildings, roads, bridges, embankments, drainage systems etc. No information has been received from Himachal Pradesh, Tripura, Nagaland, Meghalaya and Sikkim.

A number of States have expressed apprehensions and constraints. The lack of enthusiasm and keenness to enact the Bill is apparent. The major constraints which need careful consideration include (i) lack of the required hydrological data relevant to different flood frequencies, (ii) field difficulties and legal implications in enforcing land use regulation or restriction under high pressure of population and limited availability of land, and (iii) lack of an appropriate organisational infra-structure and anticipated high cost of implementing the programmes as provided in the Bill. Also, there is no field experience available in the country on flood plain zoning and land-use regulation. Further, in many quarters a strong view is held that, given the will, land use regulation in the flood zones can be enforced with the existing legal measures in force without having to enact any fresh legislation. Similar views were also held by the Ministers' Committee 1964. These constraints and the apprehensions of legal complications were brought to our notice during our discussions in the States; and we consider them to be real and reasonable. We, however, feel that in order to achieve reduction in flood damage in real terms, strict enforcement of land use regulation in flood zones and drainage channels are very essential. We therefore recommend that where existing legislation allows, flood plain management measures should be taken under the existing laws and where existing laws do not enable enforcing such measures suitable legislation should be undertaken. As an immediate measure, we further recommend that State Revenue Departments, through their lower functionaries and Panchayats, should take up physical demarcation of chronically flood prone areas along rivers, showing appropriately the maximum flood level experienced so far on demarcation pillars. This, in our view, will create large-scale public awareness of the flood risk and restrain costly investments in the high-risk flood plains.

11.6.6. The existing legal provisions on the use of land and water resources dealt with in the previous paragraphs are far from being exhaustive. The brief overview on the subject, however, makes it clear that the existing legislative measures are different in different States and lack uniformity, although their strict enforcement can help to achieve land-use regulation, including in the flood plains.

As brought out earlier, measures like land treatment, soil conservation, watershed management and land-use regulation, to be effective, should be adopted on the basis of an entire river basin or sub-basin. As most of our flood-prone rivers are inter-State in nature, it is necessary to have some uniformity in the legislative measures relating to use of land and water resources. A high-power body at the Centre in collaboration with similar bodies at the State level could attempt a review of the existing legal measures regulating the use of land and water resources or closely related issues in the country. In this context, the Commission's attention has been drawn to the directive issued in December 1974 by the Union Minister of Agriculture and Irrigation to Chief Ministers of States (Annexure 11.2) stating that the Government of India have since decided to set up a Central Land Use Commission which will keep a continuous watch on all matters pertaining to the management of country's land and soil resources. The States were requested to set up State Land Use Boards more or less on similar lines. In response to this directive, most of the States have already set up high-power Land Use Boards. According to the guidelines issued, these Boards are to draw up perspective 25-year plans for land use after making assessment of the land resources, their use, protection against fertility depletion, destruction, loss, optimum land and water utilisation in command areas, preventive measures against siltation of reservoirs, problems of rain-fed land, control of shifting cultivation, waste lands for grasses and trees, drainage and reclamation of waterlogged and salt-affected land etc. In this connection, it is understood that even though the State Land Use Boards have been already set up, the Central Land Use Commission has not yet come into being. In its absence, effective co-ordination of the activities of the State Boards as originally envisaged will not be possible. We, therefore, recommend that the proposed Central Land Use Commission should be set up at an early date. These high-power bodies at the Centre and the State level should also examine the existing legislative measures concerning land use and bring about necessary uniformity in the legal provisions for basin-wise enforcement.

11.7. Cropping strategy and catchment management

11.7.1. *Most flood prone five States*

The Commission has examined in some detail the land use problems in the chronically flood prone basins of the Indo-Gangetic river system, the Brahmaputra and Mahanadi group of west-flowing rivers. From the flood damage figures supplied by the Central Water Commission, on the average (1953—78), about 3.5 million hectares of crop land in the country are annually affected by flood, out of which 2.6 million hectares occur in these basins. Compared to the aggregate production of foodgrains achieved now in the country, the production loss due to flood damage may not appear to be of significance at the national level. Annexures 11.3 and 11.4 indicate the extent of average crop area damaged by flood in recent years in the chronically flood prone 5 States of Assam, Bihar, Orissa, Uttar Pradesh and West Bengal. It will be seen that at the national level, the average crop area annually affeced by flood in recent years comes to about 4.4 per cent of the average net sown area. In case of the chronically flood prone 5 States however the figure varies from 7.25 per cent to about 12 per cent. Even so, there appears no relation between the crop area affected by flood and the kharif production of foodgrains. Unlike the farmers of the drought affected regions, cultivators in the flood affected areas either recover the crop growth or replant the affected areas or, where flood occurs late, reap larger harvests of 'rabi' crop, availing the flood benefits. Thus, one may generally expect much less undulation in food production due to flood. Obviously, therefore, agricultural programmes for drought-affected areas so far have received more attention than those for the flood-affected areas. However, farmers suffer from operational problems and loss of their labour, inputs etc. To some extent, relief measures and the supply of seeds, seedlings, etc. by the concerned State Departments help retrieve the losses. For a closer view, however, the agricultural problems and programmes as occur in the chronically flood prone flood plains have been chosen here for specific consideration over and above those dealt in the earlier paragraphs.

11.8. Assam

11.8.1. Floods in the Assam valley may be viewed in 2 broad categories *viz.* (a) flood which is experienced in the low lying areas and (b) flood experienced in the reverine areas, neighbouring the river channel which get inundated by bank spills. In low-lying areas, storm-water runoff from neighbouring areas and the spill water from the over-flowing channels or rivers start entering in May and June and remains standing up to depths of 1 to 5 metres, till October and November. According to situation, low-lying areas submerged with water up to a depth of 1 to 3 metres are locally known as shallow-water areas while those sub-merged up to a depth of 3 to 5 metres are called deep water areas. In the reverine tracts, the first wave of flood generally comes due to overflowing rivers, some time in the first week of June, with 2 or 3 intermittent spells subsequently, depending on the intensity of rainfall in the catchments and the valley. These sudden spates of intermittent floods are fraught with danger for crops and life unlike those of the first category. Such inundations damage standing crops and deposit silt of varying fertility value. Flood deposits, predominantly of fine fraction, are highly valued by farmers for a bumper crop that follows, while deposits of coarse sand generally reduce the productivity of good land. Duration of flood on each occasion varies according to the river stage, and submergence with muddy water affects the standing crop differently. During the period 1953 to 1978, the maximum total area and maximum crop area affected by flood in any one year have been reported to be of the order of 31.5 lakh hectares and 9.2 lakh hectares respectively. The annual average, however, is said to be about 4.5 lakh hectares of total land and 1.9 lakh hectares of cropped area. When flood occurs in early June, standing crops of 'ahu' paddy and jute get damaged. Of the two, jute crop, if sown earlier and is tall enough, suffers less damage but 'ahu' crop which matures in July suffers most before its harvest. The floods of July and September cause the maximum damage. This seriously affects the 'sali' paddy, which is the main kharif crop, grown over 75 per cent of the total paddy area in the Assam valley. In case the flood level is not very high in July-August, there are chances of replanting, subject to the constraints of supply of seeds and seedlings. But when floods occur in late August or early September, a total loss of 'sali' paddy is feared as no time for replanting is available at this late stage.

In view of the foregoing a restructuring of the cropping strategy is considered essential for intensifying crop production during the flood free season of 9 months from September to May. The success of such a strategy hinges most on the availability of lift irrigation from surface or underground water sources which are abundant in the valley. The increasingly available newer technology and short-duration crop varieties with better yield potential offer great scope for restructuring the cropping strategy which is already in the offing in Assam.

11.8.2. According to the State reply, the Department of Agriculture is promoting a cropping strategy for the main paddy crop in flood prone areas and the strategy is gaining farmer's acceptance where some irrigation facilities are available. The strategy envisages raising early 'ahu' paddy from February to June, followed by late transplanted 'sali' paddy from September to December. Irrigation water is needed for planting early 'ahu' paddy while the same is required to save 'sali' paddy from moisture stress during droughty periods experienced in the post-flood season. Under irrigated conditions, a cropping programme of early 'ahu' paddy or jute in the pre-flood season and wheat, or mustard or pulses during the post-flood season, has therefore, been advocated. In the low-lying deep water areas, crop mixture of 'thu' paddy and 'bao' paddy is in practice. When flood damages 'ahu' paddy, 'bao' paddy takes over. With the recession of flood, stem of 'bao' paddy falls over the ground surface where roots strike at the nodes, putting up shoots to grow and bear grain. The 'bao' crop is harvested in November and December. If water depth is low 'asra' paddy is raised as the companion crop for which varieties like 'Saila Badal', and 'Dhala Badal' are available. For 'bao' paddy, varieties like 'Kekoa Bao' and 'Negheri Bao' are recommended.

11.8.3. Studies on the raising of paddy before and after flood have been conducted by scientists of the Agricultural University of the State. Their results support the cropping strategy of raising early 'ahu' paddy followed by late 'sali' paddy. With the availability of some irrigation water, paddy varieties maturing in 110 days are chosen so as to harvest the crop before the onset of monsoon in the first week of June. Since enough rains occur from April onward, paddy transplanting done in first week of March will need irrigation water besides the water requirements of the nursery in mid-February. Varieties suggested are CH-63 and Pusa 221 paddy. In case early 'ahu' paddy is to be grown rainfed, a 90-days duration variety like RP 79-23 (87-92 days) may be directly sown for harvesting the crop before floods. As regards the paddy crop after flood, photo-insensitive dwarf varieties are not cold-tolerant to be planted after August. There are however photo-sensitive tall indica varieties like 'Manohar Sali' which can be transplanted up to early September, and harvested by the end of December with 4 tonnes of grain yield potential per hectare. The transplanting of this crop has to be done using 50-60 day-old seedling with closer spacing of 15×25 cm. and high level of fertilisers. Short duration varieties like Pusa 2-21 and RP 79-23 which mature within 90 days with good yield potential can be transplanted up to the end of September. Researchers are in the pre-release stage for a promising strain of photo-sensitive dwarf variety from selections of Kmj 1, a cross between Manohar Sali and I.R.8. Similarly efforts are on for developing cold-tolerant paddy varieties.

In consideration of these facts, we recommend that (i) the flood-escaping cropping strategy of early 'ahu' paddy followed by late transplanted 'Sali' paddy for the flood-prone areas in Brahmaputra Valley should be extended, (ii) in support of this programme, efforts for the supply of irrigation water from shallow tubewells and low lift irrigation points may be encouraged, and (iii) further research should be undertaken to evolve cold-tolerant paddy varieties.

11.8.4. Jute is another important kharif crop which is raised, rainfed and gets affected by flood inundation. This crop is generally planted in the valley some time in March-April. The early planted jute is tall enough to stand the flood better but due to failure of early rains, the late-planted jute suffers most from flood. Provision of irrigation water for early planting of jute would substantially reduce flood damage. Among the rabi crops, pulses and oilseeds are popularly raised with residuary moisture in paddy fallows. Wheat is a new introduction to the State but is becoming popular because of a yield potential of more than 2 tonnes per hectare. The wheat crop is seeded in November and harvested in March. In districts like Lakshimpur, Dibrugarh and Sibsagar, wheat yield suffers loss as showers are received at the harvest stage. So shorter-duration varieties like Sarbati Sonora should be popularised. However, wheat may not make it possible to raise another crop during the flood-free season unless a short-duration pulse or oilseed crop precedes wheat sowing in November. For such double cropping and better yields, irrigation water in the flood prone areas, is considered essential.

11.8.5. In flood prone areas storage is a problem. Generally, people in the valley provide grain stores about 0.5 to 1 metre above the ground. During high floods, this height over the ground for grain store often becomes inadequate and grains are damaged by flood water. Raised store houses for grains above the maximum flood level are considered essential. We therefore recommend that for chronically flood-prone areas the State Government should (i) evolve improved designs of grain stores for use by farmers, (ii) undertake construction of community grain stores, and (iii) intensify research in this regard.

11.8.6. The upper catchments of Brahmaputra basin in the country fail mostly in the surrounding hill areas. They seriously suffer from faulty land use, cropping on steep slopes without terracing, shifting cultivation, deforestation, over-grazing, land slides, roadside erosion etc. In consequence, these catchments produce flashy floods and high rates of sediment discharge. There is a sizeable population occupying these hill catchments and their activities substantially contribute to the flood problems in the Brahmaputra basin. The data given in the Annexure 11.5 show that the north-east region has a little less than 20 million population (1971-census) with an average population density of 77 per sq.km. Cultivation is practised over 3.2 lakh hectares in this geophysically difficult terrain. Of the 11.68 million hectares of land under forest only 24.5 per cent is under reserve forest and more than 75 per cent of forest land lack proper management. About 55,090 km. of roads serve this region with a road density of 21.6 km. per 100 sq.km. as compared to an average road density of 37 km. per 100 sq.km. for the whole country.

General soil conservation measures, including terracing of crop land on hill slopes, a well planned watershed management, including improved silvi-pastoral practices and intensification of efforts for the control of shifting cultivation as advocated earlier are re-emphasized here.

11.9. Indo-Gangetic basin

11.9.1. Most chronically flood affected States in the Gangetic basin are Uttar Pradesh, Bihar and West Bengal where on an average about 11.7, 5.9 and 3.3 lakh hectares respectively of crop land were affected by floods during the period 1953-78. The State Departments have been recommending crops varieties for their flood-prone areas to minimise flood loss. In these areas the strategy of restructing cropping for intensifying production in flood free months applies. The success for such a strategy as earlier advocated, depends on the provision of irrigation water in the flood-prone areas. In fact, resourceful farmers in such areas have already taken to shallow tubewells and low lift points for irrigated cropping privately with bank funding. Such facilities have to be extended to other farmers belonging to the financially weaker sections of the society.

We therefore recommend that (i) for rapid development of flood affected areas and 'diara' land, special flood-prone area programme should be launched like the drought prone area programme or tribal area development programme, and (ii) appropriate research and development support for such a programme should be provided by the local agricultural universities and other research organisations.

11.10. Uttar Pradesh

11.10.1. Extensive riverine areas along the perennial rivers get annually inundated to varying depths according to the flood level. By and large, most of such areas lie within the meander belt of the rivers in the Gangetic plains. They are locally called 'khadir' lands in western Uttar Pradesh and 'diara' in eastern districts of Ballia, Ghazipur, etc., in the State. As there is a continuous process of destruction and accretion or reformation by the river, the riverine land is often under dispute or litigation for ownership/possession. Where the river meanders, the 'diara' land extends over a larger width ranging up to 12 km. but in straight sections of deep river bed, such land lies in thin strips along the banks. Assuming a mean width of about 8 km. per kilometre length of rivers like the Ganga, the Yamuna, the Ghaghra, the Sarda, the Ramganga, the Gomti and the Kalinadi, a technical study group set up by the Government of India (Department of Agriculture) estimated the extent of 'diara' land to be of the order of 15.41 lakh ha.

TABLE 11.6*

Distribution of estimated area of 'diara' land along different rivers of Uttar Pradesh

River	Ganga	Yamuna	Ghaghra	Sarda	Ramganga	Gomti	Kalinadi	Total
Diara area (lakh ha)	4.08	3.98	1.58	0.72	1.73	2.02	1.30	15.41

A reconnaissance soil survey of only 9 districts in the State and detailed soil survey of some selected tehsils have worked out the 'diara' area occurring in them at 7.07 lakh ha. with the following break-up.

TABLE 11.7 *

'Diara' area lying in 9 selected districts of Uttar Pradesh

District	Meerut	Etah	Farukhabad	Kanpur	Allahabad	Mirzapur	Varanasi	Ghazipur	Ballia	Total
Diara area (lakh ha)	18.8 ..	103.4 (23.5)	142.2 (23.5)	54.5 (8.9)	124.2 (17.0)	17.5 ..	14.9 (2.9)	65.8 (20.7)	165.6 (30.7)	706.9

Figures in bracket indicate the per cent of the district area as 'Diara' land.

According to the survey, it is observed that a large percentage of the area of the district is under 'diara' in Ballia, Ghazipur, Allahabad, Farukhabad and Etah.

11.10.2. According to topo-sequence, 'diara' land is generally divided into 3 categories (a) low bank or khadir region, (b) terai or slightly elevated mid-region, and (c) trans-khadir or relatively flood-free upland. There is also another way of classifying diara land on the same principle of its location with reference to the main stream or river. These are (a) main river bed 'diara' lands which lie inside the river bed with fine sand to coarse surface deposits and become available during summer months until receipt of early rains (December or January to June); mostly cucurbits (melon, pumpkins, bottlegourd, etc.) and other vegetables are extensively grown, specially when the lands lie in the urban neighbourhood, (b) main land 'diara' lands which are located on the bank of the river in varying widths and get frequently inundated during the floods in the rainy season, (c) upland 'diara' lands which lie next in contiguity with the mainland 'diara' lands on the land side, which have risen in elevation due to alluvial deposition in past and are less frequently flooded; practically up and 'diaras' are treated as normal land for agricultural purposes. These categories among themselves vary in soil character, cropping pattern and pose different problems for their development. For instance, Ghaghra 'diara' lands are calcareous and coarser in texture while Ganga 'diara' lands in the eastern end of the State are fine and clayey in texture.

11.10.3 'Diara' lands are available for the flood free period which varies from 3 to 10 months.

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*Report of the Technical Committee on Diara areas in Uttar Pradesh and Bihar, March 1972, Deptt. of Agri., GOI.

The period is shortest for the river-bed diara, where preparatory tillage commences as late as January. On main land 'diara', the crop-raising period extends from early November till June. Except in case of high flood years, the upland 'diara' lands support crops like normal land in the locality. Cropping pattern varies from place to place. Near urban areas, cucurbits (melons, pumpkins, bottlegourd) and summer vegetables are extensively grown in river bed diara, on annual lease with irrigation from the river. On the mainland and upland diara, mostly cereals, cereal plus pulses or cereal plus oilseed combinations are raised under rainted conditions. Crop mixtures are common in 'rabi' wheat plus rape/mustard, barley plus gram, barley and khesari are popular. The 'diaras' east of Allahabad extensively raise wheat and rape/mustard or barley and rape/mustard crop mixtures in 'rabi'. Khesari and lentil are largely grown in this region as sole crops. The 'diaras' around Kanpur in central Uttar Pradesh grow 2 crops of brinjal for profit. During kharif, early-maturing maize and sorghum mixtures of 60—70 days duration are grown which mature before the occurrence of major floods. Where flood water recedes late and soils are low in water holding capacity and saline, barley is preferably grown in rabi. For this reason, over 50,000 hectares under barley are reported for the districts of Azamgarh, Jaunpur, Allahabad, Unnao, Ghazipur, Varanasi, Pratapgarh and Rae-Bareli. Taking an overview of the existing and proposed cropping for flood-damage reduction a general strategy emerges as under: (a) intensive rabi cropping after recession of flood water, preferably with irrigation wheat (Sarbati Sonora, Kalyan, Sona), potato, peas and mustard are recommended as rabi crops, (b) post-rabi zaid cropping or summer cropping till onset of rains, specially with irrigation; summer maize, mung and paddy (N 22, IET 1087) of short duration should be raised and harvested before rains, (c) kharif cropping mostly with paddy varieties which can stand submergence to some degree and waterlogging. For the State, 'Madhukar' and 'Chakia 59' paddy which can stand long waterlogging and submergence up to a week, is suggested. Recognising the merit of the above strategy, we recommend it to be popularised with irrigation support. In heavily eroded and undulating 'diara' land, fruit orchards of 'ber' and guava are commonly seen. At some places like Karanda diara area in Ghazipur, the State Department and occasionally private land owners have resorted to pumping water directly from rivers for irrigation, using floating barges and electrical power. Some cultivators are using pumping sets driven by diesel engines to lift water from nearby rivers and rivulets for irrigation. Thus there exists a strong need for irrigation water and intensive crop production in the flood free season which should be further promoted by Government agencies.

11.10.4 *Land management in upper catchments*

A sizeable area of the upper catchments of the Ganga system falls in the hill region of Uttar Pradesh. The hill region consists of the Himalayas and Siwaliks, which occupy 51,123 sq. km. in the State, covering the 8 districts of Pithoragarh, Almora, Nainital, Chamoli, Garhwal, Uttar Kashi, Tehri and Dehra Dun, including the most erodible tracts of Sivaliks ravaged by hill torrents in the districts of Saharanpur and Bijnor area* of the hill region, the upper catchments account for about 57,400 sq.km. of the State. Eight of the hill districts mentioned earlier have together a large population of some 3.8. million in 1971 and estimated to be around 4.3 million in 1977. According to the estimates of 1977 the density of population works out to be 85 per sq.km. This is indeed quite high for the mountain region. A vast population of livestock also overgraze the hill region. According to district-wise census figures (1972-74) the eight hill districts have a cattle population of over 2 million and over 1 million of sheep and goat. Thus, there is heavy livestock pressure in this region. The available quantity of feed and fodder for such a large number is far from being adequate. Nomadic grazing, overgrazing and heavy lopping of tree for fodder in these hill districts are rampant, and have rapidly denuded the hills.

Out of some 33,541 sq.km. of forest land (including those above snowline) in the 8 hill districts, about 23,790 sq. km. of forest area comes under the control of the State Department, and the remaining 9,771 sq. km. are under civil and "Soyam" forest, panchayati forest, or under private or municipal ownership. Such large forest areas, not under the control of Forest Department, are riddled with problems of rights and privileges. In consequence, they are devoid of adequate vegetative cover and constitute the sore spots which generate high rates of runoff and sediment discharge. We have already dealt with the watershed management programme in forest land earlier and the recommendations offered there hold good here.

There are, in all, about 5.97 lakh holdings in the upper catchments of the 8 hill districts. Of these nearly 39 per cent are less than 0.5 to 1 ha. These tiny holdings on steep hill slopes pose serious problems of management. Hence we recommend hill terracing as a general rule for minimising runoff and sediment discharge.

11.11 Bihar

11.11.1 Like in the eastern region of Uttar Pradesh, 'diara' land in Bihar constitutes most of the flood-affected flood plain area in the State. The general characteristics of 'diara' land described in case of eastern Uttar Pradesh hold good here also. The Technical Group on Diara Area,

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**Source:* Afforestation and Land Use Development or Uttar Pradesh Himalayas and Siwaliks, Uttar Pradesh Forest Department, October 1979.

Department of Agriculture, 1972 have given the total 'diara' area in Bihar to be about 8.63 lakh ha. as follows:

TABLE 11.8

Estimated Diara area in Bihar

River	Ganga	Gandak	Burhi Gandak	Sone	Kosi	Total
Diara area (lakh ha)	2.40	1.40	2.25	1.13	1.45	8.63

As the problems and constraints of diara land in Uttar Pradesh, by and large, apply to the Bihar diara also, we advocate measures similar to those recommended in the case of Uttar Pradesh. As per the State's reply, the following cropping is currently practised in different flood prone areas of the State.

TABLE 11.9

Present cropping pattern in flood prone areas in Bihar

Flood prone areas	Crops grown	
	kharif	rabi
Ganga–Sone area	maize jowar arhar paddy	wheat barley gram mustard
Gandak area	maize arhar paddy (deep water)	wheat gram summer mung, jute
Kosi area	paddy early maize black gram	wheat barley

The State has suggested that early maize in kharif may be raised which can be harvested before the monsoon flood. In fact, kharif maize is an important cereal grown over 6.0 lakh ha in the flood-affected districts of north Bihar and is preferred to other crops. High-yielding, composite maize varieties are available to meet the needs of the farmers in the flood-affected north Bihar. In the standing 'rabi' crops of wheat or barley in main land or upland diaras, seeds of cucurbits and vegetables are sown in well-manured small holes, before the harvest of wheat or barley crop. After the harvest of wheat or barley, the young plants of cucurbits, vegetables, etc. establish well and supply the summer vegetables.

11.11.2 There is an essential need for irrigation water to itensify cropping in the flood-free months. Farmers have taken to shallow tubewells, low-lift pumping from surface water sources etc., for raising irrigated crops. Bamboo tubewells in the Kosi area have been popular. Thus, intensive crop production with shallow tubewells and low lift irrigation points, shows the pathway for increasing agricultural production in flood-free months. Some of the irrigated crop sequences have been suggested by the State. They include (a) hot-weather summer maize followed by 'rabi' wheat or potato and other vegetables, (b) summer maize followed by rabi wheat or (c) sugarcane. As in the eastern Uttar Pradesh, sugarcane planted in September/October or January/February grows tall enough to withstand flood inundation better than other crops. Some of the other crop rotations for unprotected flooded area in north Bihar are:

Gandak area		Kosi area	
Kharif	rabi	Kharif	rabi
maize	wheat/gram & mustard	fallow	wheat/barley
fallow	,,	paddy	wheat
maize & arhar	arhar	early maize	wheat
deep water paddy	---		

We endorse this cropping strategy

11.12 West Bengal

11.12.1 In this State summer paddy (boro) and irrigated wheat are becoming increasingly popular. Such a remunerative cropping depends on assured irrigation and there is a growing urge for shallow tubewells and low lift points. Due to high demand in the Calcutta market, vegetable cultivation is rapidly increasing with irrigation. The State Government recommends raising early paddy with irrigation for unprotected areas affected by September floods. In the protected areas normal cropping is adopted. A contingent or alternate cropping plan has been suggested for different flood situations as under:

(a) maize, jute (capsularis), til, mung, etc. may be grown early, and crop should be harvested before flood;

(b) when flood occurs in June/July but water recedes by July, seedlings should be prepared in a new nursery plot using paddy varieties like IR-20, IR-26, IR-30, Pusa 2-21, Palman 579, CNM 25, NC 1393, NC 128, and IET 2395 for transplanting after recession of flood water;

(c) when floods come in July/August and recede before end of August, seedlings may be raised in another nursery bed with paddy varieties of IR-20, IR-26, NC 1281, and NC 1393 for transplanting after the flood water recedes;

(d) for September floods, one may resort to late transplanting of overaged 60—80-day-old seedings of paddy varieties like NC 1393, Jagannath and CR 1014 with good yield expectations on harvest at the end of December. Alternately, short-duration black gram and mustard is raised before late seeding of Sonalika variety of wheat with irrigation;

(e) farmers also adopt clonal separation and transplanting if the paddy crop is partially damaged;

(f) when flood occurs in October, land should be prepared for irrigated wheat or unirrigated gram, lentil, or oilseed crops.

The constraints experienced in executing the contingent plans are inadequate availability of seeds, seedling and funds besides the inadequacy of pumps for evacuating flood water and land preparation for the next crop. With irrigation facilities, a cropping strategy has been recommended with early jute (capsularis) followed by late transplanting of photo-sensitive paddy like CR 1014, Jagannath, etc., using 60-day-old seedlings. Also wheat or mustard followed by summer paddy could be another choice with irrigation. In the flood prone areas of north Bengal early rains are received in February-March. Here jute-paddy rotation is popular. Early jute (capsularis JRC 321) is sown with rains in February-March and harvested in July. Due to its height the crop does not suffer much from early flood. After jute, paddy varieties of Jaladhi I and Jaladhi II which are tolerant to excess water, have been recommended. Local jute variety like 'Bidya Sundari', reputed for flood tolerance, is another choice for flood-prone areas.

11.13 Orissa

11.13.1 The coastal districts of Puri, Cuttack and Balasore are flood prone. The nature of crops varies with the location of land, and depth and duration of the flood, although the occurrence, intensity and duration of flood are uncertain. In general, for low and medium land experiencing long-duration flood with shallow depth, kharif rice followed by rabi pulses like mung or 'urad' (biri) in rotation is popular with the farmer. For uplands experiencing short duration floods, jute followed by paddy followed by 'rabi' vegetables, or potato or oilseed are common with irrigation.

The following cropping sequence has, however, been recommended by the State Government.

TABLE 11.10

Recommended cropping pattern, Orissa

Land situation (topo sequence)	first crop	second crop	third crop
irrigated high & medium land	jute	paddy	pulses/oilseeds
	early paddy	—	wheat/pulses/oilseeds
medium & low .	jute	paddy	paddy
low . . .	paddy	paddy	—
Unirrigated	jute	paddy	
		paddy	pulses/oilseeds
	jute	—	oilseeds

The first crop is sown in mid-June both for irrigated or unirrigated paddy. Jute is sown in April/May and harvested by the end of August or early September and the second crop of paddy is transplanted immediately and harvested by the end of December or early January. Irrigated third crop of paddy or pulses/oilseeds is sown during the second half of December or early January. In case of unirrigated cropping the second crop of pulses or oilseeds is sown in December or January after paddy. In Orissa, lift irrigation from river, tubewell, and dug well are increasing for intensive cropping in flood-prone areas. They will eventually minimise or obviate the production loss due to flood. At present, the Department of Agriculture keeps ready with the contingent cropping plans to

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meet the flood situations. According to the local situations, intensive cropping pattern of jute-paddy-pulses/oilseeds for irrigated areas and jute-paddy, jute-oilseeds, or paddy-oilseeds for unirrigated areas have been recommended. The farmers in the flooded areas are advised to use flood resistant paddy varieties of FR.43-B, FR. 13-A, evolved for such conditions.

While endorsing these rotations in general as in other flood prone States, we recommend development of lift irrigation to intensify production in flood free months.

11.14 Jute and sugarcane

11.14.1 These are important crops which get flood affected during the monsoon floods. Jute (only capsularis) based rotations have often been advocated and are in practice in the chronically flood prone areas. Some of these jute-based rotations suitable for flood prone States are. (i) jute followed by photo-sensitive 'Manoharsali' paddy for lower Assam valley and northern West Benbal, (ii) jute-tall indica paddy or early paddy and deep water paddy for Goalpara, Kamrup and Nowgong districts of Assam, (iii) jute-wheat or jute-mustard for southern West Bengal, (iv) jute followed by late paddy or paddy-onion for low land Kosi region of Bihar, (v) jute-wheat or jute-pea for the north-west Bihar and eastern Uttar Pradesh, (vi) jute-paddy (T-141 paddy, photo-sensitive) in Gangetic West Bengal, (vii) jute-paddy in general for the flood prone deltaic districts (Puri, Cuttack and Balasore) and jute-paddy, paddy-pulses or early paddy-late paddy for low lands in Orissa.

11.14.2 *Sugarcane*

This crop is not very tolerant to waterlogging and the degree of tolerance varies from variety to variety. Often, this crop is grown in the riverine areas as in Haryana, Uttar Pradesh, Bihar, and is subjected to submersion of more than a metre depth of flood water, sometimes for several weeks. This occurs 2-3 times in the monsoon months of July-August in eastern Uttar Pradesh and north Bihar. Researchers have studied these problems and recommended suitable varieties (Annexure 11.6) for waterlogged areas like the varieties of CO.1007, CO. 1157, CO.S.633, etc. for Uttar Pradesh and CO-P1, CO-P2, BO-17, BO-76 etc. for Bihar. As waterlogged conditions are conducive for the spread of the disease of red-rot, planting material should be selected from hot air and hot-water-treated nurseries and treated with Agallol (0.5 per cent) or with aeretan (0.25 per cent) before planting. The time of planting is considered critical for escaping serious damage from flood or waterlogging. Generally the timing of planting is adjusted to avoid waterlogging at the stage of germination and the juvenile phase of plant growth. In consideration thereof, sugarcane planting in chronically flood prone areas in eastern Uttar Pradesh and north Bihar has been recommended to be taken up early in the season between January to mid-February so that canes can grow tall enough to withstand the flood. Similarly cane planted in August-September suffers less from flood water due to its height, although there may be a slight depression in the sucrose content.

We consider these practices to be valuable for the cane growers in the flood prone areas in eastern Uttar Pradesh and north Bihar and recommend them for popularisation. As a flood-escaping strategy early planting of jute in March-April and sugarcane in January-February requires irrigation water and we recommend that irrigation facilities should be improved for these crops in the flood prone areas.

11.15 Deep-water paddy

11.15.1. In chronically flood prone areas, there are extensive tracts where flood water stands for long periods. In such situations water depths range from 0.5 to 5 metre, during June to December. These low-lying depressions are known as 'chaurs' in Bihar, 'jheels' in Uttar Pradesh and 'beels' in West Bengal and Assam. About 2-3 million hectares of such areas are covered with deep water paddy or floating paddy, with low grain yields of 0.5 to 1 tonne per hectare. Of this, about 25 per cent of the area is deep with more than 50 cm water depth and the rest are under shallow water areas with less than 50 cm water depth. After Independence, studies on improvement of deep water paddy were undertaken mainly at Chinsura (West Bengal), Pusa (Bihar) and Goghraghat (Uttar Pradesh). These efforts have recently been intensified. As a result, improved varieties (Annexure 11.7) like 'Jalmagna' and 'Madhukar' from Uttar Pradesh, BR. 14, BR. 15, BR. 46, and 64.1171 pure line selection from Bihar, Jaladhi I and Jaladhi II from West Bengal have been recommended for deep-water paddy areas. Local and exotic floating types have been crossed with semi-dwarf paddy varieties like IR-8, Jaya and Pankaj, and many more improved selections are in the offing for deep-water flood situations. Deep-water paddy is estimated to occupy 25 to 30 per cent of the world's total paddy-growing area. There are extensive areas of deep-water paddy in south-east Asian countries like Bangladesh, Burma, Thailand and Vietnam. Hence, international programmes have also been launched to improve this crop. For shallow-water locations, the deep-water paddy varieties available are BR. 7 and BR. 8, with yield expectations of 2-3 tonnes per hectare for Bihar, Latisal and Patnai 23 for West Bengal, Manoharsali for Assam and T. 141 for Orissa. These are performing well. Till there is an organised programme to develop the deep portions of such inland water bodies as deep water reservoirs, and draining of the shallow-water areas in the margins for cultivation with irrigation from the developed reservoir, the existing practice of floating paddy or deep water paddy will continue.

In view of the foregoing, we advocate that (i) the deep water paddy areas should be systematically surveyed, production constraints identified, and research-cum-operational projects implemented under an all-India co-ordinated project to benefit the farmers in the flood-prone areas, and (ii) research efforts on deep-water paddy should be further intensified for genetical and agronomic improvements in order to stabilise per hectare yields at a higher level.

11.16 Tals, 'Chaurs', 'Jheels' and 'Beels'

11.16.1 Numerous saucer-shaped depressions occur in the chronically flood prone plains in eastern Uttar Pradesh, north Bihar, West Bengal and Assam. These are locally known as 'jheels' in Uttar Pradesh, 'chaurs' in Bihar and 'beels' in West Bengal and Assam. They provide surface storage. Due to the meandering nature of the Gangetic river system, many ox-bow lakes called 'mans' occur in the north Bihar plains. As the water recedes in the 'chaurs' or 'beels' after the monsoon, the land is hurriedly prepared for a good crop with the residual moisture and the beneficial effects of fresh silt. Since these depressions are connected to the nearby river, flood water enters the depressions and stands there as back water for long time. As a result, the fine particles accumulate and the soil becomes heavy with low hydraulic conductivity. Although highly moisture-retentive, these heavy clayey soils pose problems for preparatory tillage with only a short time available for seed-bed preparation.

Recently there is an increasing demand for draining of these depressions permanently for agricultural crops in the Gangetic basin. These drainage schemes are costly. In apprehension of the loss of surface storage and the high cost of such drainage schemes, we have considered the scope of fishery as an alternate use of these derelict water bodies. From our discussions with fisheries experts and research scientists of the Central Inland Fisheries Research Institute, Barrackpore, we feel that pisciculture offers a highly profitable use of such inland water bodies. For the purpose, improved fish culture technology is also available in the country which will produce annually about 2 tonnes per hectare of water area, although fish yields of 5 tonnes per hectare per year has already been obtained in some of the East Asian countries. On the basis of the information received from the States and the Report of the Inland Fisheries Technical Committee (1973) of the Central Board of Fisheries, we feel that the derelict inland water bodies offer large scope for pisciculture.

11.16.2 *Brahmaputra valley—Assam*

Two kinds of 'beels' occur in the Assam valley *viz.* (a) lake like 'beels' and (b) ox-bow beels. They are mostly shallow, in the marginal areas and are ordinarily connected to the nearby rivers. Due to cilting over the years, the river connections in many cases have become defunct. 'Beels' have also been heavily infested with weeds like water hyacinth (Eichhornia crassipes). An area of about 0.49 lakh ha is under such inland water bodies in the Assam valley. With the adoption of improved technology it offers an annual production potential of 70,000 tonnes of fish, as against the present production of 10,000 tonnes only. The Technical Committee on Inland Fisheries has already suggested a strategy for the 'beel' fishery development. These suggestions include (i) the promotion of culture fisheries in the marginal areas by construction of ponds, (ii) development of capture fisheries in the rest of the 'beel' area, and (iii) deepening of the connecting channels to the river and providing sluice gates. A 'beel' fisheries Development Authority has been suggested for the State which will provide the necessary technical and financial support and implement the programmes through Fish Farmers Agencies to be set up in each district.

11.16.3 *North and south Bihar plains (Ganga basin)*

Ox-bow lakes are very common in the chronically flood prone flood plains of north Bihar, locally known as 'mans'. basides the 'tals' and 'chaurs'. There are about 50 'mans' in north Bihar covering about 3,845 ha. Being abandoned river courses, their size depends on the original river. Some of them have retained their connections with main river course and receive water only during floods, while connections in the others have completely silted up. Also the ox-bow lakes themselves have been considerably silted up and are heavily infested with acquatic weeds. Construction of flood embankments in the past have, in fact, ignored them and in consequence, river connections of some of the 'mans' have since been blocked, thereby affecting the auto-stocking of spawns. The concerned departments in the State are seriously considering the development of 'mans' fishery with improved fish technology and the guidelines given by the Technical Committee mentioned earlier.

11.16.4 *West Bengal*

'Beels' occur extensively in the flood plains of the Gangetic West Bengal and they occupy about 0.8 lakh ha. They were mostly under the private ownership but due to the implementation of the Estate Acquisition Act, 0.4 lakh ha of beels are now vested in the State Government. As a result of years of neglect, the river links of many 'beels' have been silted up, turning them into closed swamps. Some of the 'beels' are heavily infested with a variety of acquatic weeds. Hence there is very little evidence of improved fish culture practised in 'beels' although their wild stock of fish is regularly netted. In earlier days, through the river links, 'beels' used to receive spawn and fry along with flood water during high floods, and capture fishery was flourishing.

Now to develop these derelict 'beels' for profitable fishery, the developmental cost has been estimated to be Rs. 5,250 per hectare (1973 prices) for preliminary works like deweeding, repairing, embankments and sluice gates. Based on this estimate the State Government has implemented a scheme for development of 'beel' fisheries.

11.16.5 The National Commission on Agriculture has considered beel fishery and in its report (1976) has stated that the extent of derelict fresh-water resources would be approximately 4 lakh hectares in Uttar Pradesh, Bihar, West Bengal and Assam. Of this, 1 lakh ha can be developed as fish ponds along the margins. The NCA has therefore recommended. "The State Governments should consider these as exclusively fishery resources while considering the land and water utilisation policy and other interests, if any, should be deemed to be incidental to the fishery development." According to the national strategy for fish production contained in the Five, Year Plan document 1978—83, additional fish production will be undertaken through development of large water areas under beels, swamps, ox-bow lakes and through systematic development of reservoirs.

In consideration of these points and the importance of retaining valley storage for flood moderation, we recommend that no large scale drainage scheme of reclamation of 'beels', 'chaurs' or 'jheels' should be taken up without considering their other alternative uses for fishery, irrigation, biological sanctuary for tourists and the like.

11.17 Livestock programme

11.17.1 Riverine areas in extensive 'diaras' are considered ideal for livestock development and dairy. While visiting Kosi 'diaras' we were convinced about the role of the livestock in improving the lot of 'diaras' dwellers. In fact, the riverine tracts in northern India are known for cattle wealth which has been the main stay of livelihood of 'gwalas' there. Well known cattle breeds of 'Ganga Tiri' and 'Shahabadi' are still considered efficient milk producers in Varanasi, Ghazipur, Ballia and Shahabad. Murah buffaloes are found to be popular in 'diaras' areas. In our view, the 'diaras' land offers excellent grazing land due to year-round water availability and annual silt deposits. The flood period, however, remains the major constraint when large herds shift to the mainland for safety and grazing. They return after flood to graze the luxuriant grass growth that flourishes in the river-bed 'diaras' after flood. The graziers mostly belong to the 'gwala' community. They generally do not own much land and live by keeping and breeding cattle and milk production. Besides the 'gwalas', every 'diara' farmer also maintains a few milch and drought animals. During rabi season these cattle are well fed with leguminous weeds, and crops like mustard, gram and peas. After the rabi crops they graze the harvested fields. Only rainy seasons poses the problem of fodder scarcity and coincides with the breeding season for buffaloes. As the post-flood season produces luxuriant vegetation for fodder, one may consider hay and silage making to get over the fodder famine during the floods. Besides, suitable fodder crops need to be integrated into the cropping programme of the 'diara' land farmer. For the large population of 'gwalas', organised 'range-feedlot' system of livestock management on a co-operative basis offers great scope to improve their lot. Under such a system, except during the flood prone rainy season, the cattle live on the improved pastures in the 'diara' consciously developed for the purpose. Feed lots with shelters on the mainland are organised as part of the system into which the 'diara' graziers with their livestock move in for the rainy season with payment. When rains are over they return to the 'diara'. For success of this system, marketing system has to be planned on the pattern of Gujarat dairy co-operatives. We therefore, recommend that (i) suitable 'range-feedlot' system of cattle development for the economic uplift of the river-bed 'diara' graziers should be taken up on a pilot scale to determine its feasibility before its large scale extension, and (ii) under the on-going Operation Flood Phase II Programme, some of the 'diara' districts like Ballia, Ghazipur, Monghyr should be included for immediate benefit to the 'diara' graziers.

ANNEXURE 11.1

[Ref. Para 11·3·4]

Progress of soil conservation works in the catchment of River Valley Projects

(Area in 000 ha.)
(Rs. in lakhs)

Sl. No.	Name of the catchment	Name of the State(s)	Total area	priority area for treatment	area treated		expenditure upto 77-78
					Total up to 77-78	% of priority area	
1	Beas	Himachal Pradesh	1251	352·78	11·24	3·19	135·75
2	Bhakra (Sutlej)	Himachal Pradesh	1820	796·07	128·51	16·14	929·22
3	Chambal	Madhya Pradesh and Rajasthan	2696	900·46	196·17	21·78	547·71
4	Damanganga	Gujarat	182	90·27	Prelim.	works	4·75
5	Dantiwada	Gujarat & Rajasthan	286	70·35	44·02	62·57	204·05
6	Damodar-Barakar	Bihar & West Bengal	1806	912·03	228·15	25·01	1794·84
7	Ghod	Maharashtra	363	54·45	18·21	33·44	101·83
8	Giri-Bata	Himachal Pradesh	295	131·69	0·09	0·07	2·89
9	Gumti	Tripura	55	42·07	0·02	0·05	0·50
10	Hirakud (Mahanadi)	Madhya Pradesh and Orissa	8339	1250·85	205·43	16·42	974·42
11	Kangsabati	West Bengal	379	159·18	47·55	29·87	204·85
12	Kundah	Tamil Nadu & Kerala	126	18·90	17·36	91·00	183·45
13	Lower Bhavani	Tamil Nadu	615	218·32	3·71	1·70	52·43
14	Machkund	Andhra Pradesh & Orissa	222	99·90	62·43	62·49	429·87
15	Mahi	Gujarat, Rajasthan and Madhya Pradesh	2548	1044·68	15·1	1·45	91·75
16	Matatila	Uttar Pradesh and Madhya Pradesh	2072	636·10	31·01	4·87	150·49
17	Mayurakshi	Bihar	186	76·07	29·59	38·90	186·87
18	Nagarjunasagar	Andhra Pradesh, Maharashtra and Karnataka	21497	6492·09	15·67	0·24	13·76
19	Nizamsagar	Do.	2169	316·67	8·12	2·56	61·40
20	Pagladia	Assam	118	66·32	0·67	1·01	11·66
21	Pochampad	Andhra Pradesh & Maharashtra	9072	3773·95	2·11	0·06	35·06
22	Pohru	Jammu & Kashmir	186	62·49	8·28	13·25	73·64
23	Ramganga	Uttar Pradesh	313	105·17	42·00	39·93	341·48
24	Rengali Mandira	Madhya Pradesh, Orissa & Bihar	3150	809·55	4·61	0·57	40·76
25	Sone	Bihar and Madhya Pradesh	5995	1049·25	0·65	0·06	3·76
26	Sukhna Lake	Chandigarh	4	4·00	Prelim.	works	—
27	Tawa	Madhya Pradesh	598	198·53	2·09	1·05	3·19
28	Teesta	West Bengal & Sikkim	1266	746·43	0·12	0·02	6·78
29	Tungabhadra	Karnataka	2818	422·70	127·26	30·10	325·63
30	Ukai	Maharashtra, Gujarat and Madhya Pradesh	6222	2743·90	6·68	0·24	42·18
		Total	77649	23645·22	1156·89	5·31	7009·91

NOTE 1. Anticipated physical achievement during 1978-79—83,000 ha.

2. Anticipated expenditure during 1978-79—Rs. 1000·00 lakhs.

3. Soil Conservation Branch, Department of Agriculture, Government of India.

ANNEXURE 11.2

(Ref. Para 11.6.6)

JAGJIVAN RAM
Minister of Agriculture and Irrigation
Government of India

New Delhi December 4, 1979

D.O. No. 274/M(A&I)/D/74

Please refer to Shri Ahmed's letter No. 1361/MFA/74-F dated the 20th May, 1974, in which we had suggested the setting up of a State Land Use Board which should be responsible for ensuring that the State's land and soil resources are used to the best possible advantage and are not allowed to be depleted any further.

2. It has since been decided to set up a Central Land Use Commission which will keep a continuous watch on all matters pertaining to the management of the country's land and soil resources. This Commission will be headed by the Minister of Agriculture and Irrigation and will have a whole-time Vice-Chairman, whole-time Member Secretary and two or three whole-time members in addition to a number of part-time Members.

3. I would suggest, for your most serious consideration that your Government may set up a State Land Use Board more or less on the same lines as the Central Land Use Commission. In view of the extreme importance of the subject, I feel it would be appropriate for such a Board to be presided over by the Chief Minister and to have as its members the State Secretaries for Agriculture (including soil conservation and soil surveys), Forestry, Irrigation Revenue, Panchayats, Town and Country Planning, Planning and Finance. A whole-time officer of the rank of Secretary to the State Government and who would function under the overall control and guidance of Agricultural Production Commissioner—may be appointed as Member-Secretary of the Board and made responsible for all land and soil management programmes in the State. A list of such programmes as mentioned in the draft 5th Plan is enclosed (Appendix—I).*

4. I would request for very early action for the constitution of the Board and the appointment of its Member-Secretary so that no time may be lost in making a start with a comprehensive appraisal of the State's land and soil management problems. I would suggest that the Board may prepare, as early as this may be possible, a perspective 25-year programme for the assessment and optimum management of the State's land and soil resources so that this may provide a rational framework for the yearly and five-yearly plans for land and soil management to fit into. In this connection I am enclosing at Appendix-II, a set of guidelines which may be of use to the Board in drawing up the State's perspective Plan.

5. As you are already aware, the Prime Minister is anxious that we should come to grips with our land and soil management problems without any further delay. I accordingly propose to call a meeting of Chief Ministers to discuss these matters with them within the next three months or so. However, in order to prepare the ground for such a meeting we propose, in the first instance, to call a meeting at the official level of Member-Secretaries of all State Land Use Boards some time towards the end of January, 1975. This would however be possible only if decisions regarding the constitution of State Boards and the appointment of their Member-Secretaries are taken almost immediately.

6. I should be grateful for a line in reply at your earliest convenience.

Yours sincerely,
Sd/-
(Jagjivan Ram)

All Chief Secretaries.

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*This appendix is not reproduced here.

GUIDELINES FOR STATE LAND USE BOARDS FOR DRAWING UP THEIR PERSPECTIVE 25-YEAR PLANS

(a) A very high--priority must be given to programmes of resource assessment for the obvious reason that it is impossible to plan for better land management without knowing the extent, nature and location of the problem areas. To illustrate, land use statistics as at present compiled give no indication either at the national or State level of the reasons which lie behind land going out of use. In order however to have meaningful plans we must know why certain areas have been lying fallow for a long time, why others are described as culturable wastes and still others as barren and unculturable.

(b) Effective measures must be taken to protect good agricultural lands—which are the States' most precious assets—against depletion in areas or fertility on account of:—

- (i) erosion by wind or water or sea;
- (ii) Water logging and salinity;
- (iii) improvidently intensive agriculture in condition where more nutrients including micro-nutrients are taken out of the soil than are added to it;
- (iv) urbanisation and industrialisation.

The idea is that each State must take special measures to protect its best agricultural lands in a conscious and deliberate manner and draw up suitable plans for meeting the hazards to which they are exposed.

(c) A very large sum—Rs. 3500 crores or so for the country as a whole—has been invested in providing surface irrigation to around 20 million ha in the country through medium and major irrigation projects. Very energetic measures need to be taken to provide for optimum land and water utilisation in the commands of these projects in accordance with the guidelines already issued by the Union Department of Agriculture in August 1973 in order to achieve a quick increase in agricultural production.

(d) Storage of the medium and major irrigation and multi-purpose projects referred to above must be saved from premature siltation not only in the interest of safeguarding the irrigation potential but in many cases also their power potential. This is a problem of colossal proportions to which very little attention has been paid so far.

(e) Problems of rainfed agriculture must be given special attention in drought prone areas. We must completely break away from the existing practice of carrying out so-called soil conservation measures which are described as contour bunding but are in reality nothing more than field bunding. What is required is to construct bunds along actual contour lines even if this means the undertaking of consolidation operations in such areas so as to redraw field boundaries in accordance with the lie of the land. Such operations must also take account of the needs of the rest of the catchment for land treatment and must also be followed up by extension work which will enable the farmer to increase the productivity of the land. Since no State is at present in a position to undertake such integrated operations we must be prepared for delays in this sector—these delays will however be preferable to the continued incurring of infructuous expenditure.

(f) The control of shifting cultivation, which is leading to very heavy soil erosion to the affected areas must be taken up on a priority basis by the concerned States.

(g) Large blocks of denuded lands which are unfit for cultivation disfigure the landscape in almost all parts of the country. Such lands are known to be capable of producing large qantities of grasses and trees if properly protected from the ravages of men and beast. Ways of ensuring such protection must be considered and put into operation. Among these ways will be control over grazing by nomadic flocks and a reduction in the number of cattle, sheep and goats owned by nomadic herdsmen.

(h) The reclamation of waterlogged and saline soils must be undertaken by drainage and other means.

ANNEXURE 11.3

(Ref. Para 11.7.1)

Average crop area damaged annually by floods

(*Area in lakh ha.*)

State	Average annual net sown area 1970-71 to 1975-76*	Average annual flood affected crop area (1971-78)**	Col. 3 as per cent of net own area
1	2	3	4
Assam	23.90	2.86	11.97
Bihar	83.19	8.58	10.31
Orissa	59.43	4.31	7.25
Uttar Pradesh	172.35	16.64	9.65
West Bengal	58.63	4.66	7.95
INDIA	1402.35	61.76	4.40

Source : *Indian Agriculture in Brief, 15th Edition, 1976, Directorate of Economics and Statistics, Govt. of India.

**Flood damage statements furnished by Central Water Commission, Govt. of India.

सत्यमेव जयते

ANNEXURE 11.4

(Ref. Para 11.7.1)

Season-wise food production figures for the major flood-prone 5 States in the country during 1975-78

Area in lakh hectares
Production in lakh tonnes

State	Year	Total area affected by flood**	Total crop area affected by flood**	Production of foodgrains@		
				Kharif	Rabi	Total
Assam*	1975-76	0·1	0·1	22·7	1·4	24·1
	1976-77	5·7	1·1	21·3	1·2	22·5
	1977-78	11·0	4·5	22·8	1·4	24·2
Bihar	1975-76	23·1	11·7	60·3	31·5	91·8
	1976-77	29·9	8·5	59·8	32·0	91·8
	1977-78	11·5	2·3	66·9	31·7	98·6
Orissa	1975-76	5·1	4·2	47·7	8·0	55·7
	1976-77	Neg.	Neg.	33·8	6·9	40·7
	1977-78	3·1	1·9	45·1	8·6	53·7
Uttar Pradesh	1975-76	21·8	13·8	77·2	117·6	194·8
	1976-77	36·3	21·6	79·7	119·4	199·1
	1977-78	13·0	6·1	86·1	122·2	208·3
West Bengal	1975-76	2·0	0·4	61·1	24·8	85·9
	1976-77	13·0	1·6	53·8	20·7	74·5
	1977-78	15·5	3·5	67·2	22·7	89·9
All India	1975-76	61·5	38·5	738·9	471·4	1210·3
	1976-77	178·9	76·8	665·3	446·4	1111·7
	1977-78	178·8	82·5	777·6	478·4	1256·0

Source : *Assam includes Meghalaya and Mizoram.

**Flood damage data furnished by the Central Water Comission, Govt. of India.

@ Estimates of area and production of principal crops in India, 1976-77, Directorate of Economics & Statistics, Govt. of India, 1978.

ANNEXURE 11.5

(Ref. Para 11.8.6)

*Some selected statistics relating to the North-Eastern Region**

Region	Area million sq. km	Population 1971 (millions)	Net sown area (million ha)	Forest (million ha)	Reserved forest(%)	Total road length (km)	Km of roads per 100 sq. km
1	2	3	4	5	6	7	8
(1) Northeastern Region	0·26	19·58 (77)	0·32	11·68	*24·5*	55,000	*21·6*
(2) India	3·28	547·95 (167)	136·78	67·41	47·0	1215337	*27·0*

*The North-eastern region consists of Arunachal, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura.

Figs. within bracket are density of population per sq. km.

Col. 2, 4, 5 & 6 :	Indian Agriculture in Brief, 15th Edn. 1976, Directorate of Economics and Statistics, Govt. of India.
Col. 3 :	Census of India 1971, Series 1, India, Registrar General and Census Commissioner, Govt. of India.
Col. 7 & 8 :	Road Statistics of India, Transport Research Division, Ministry of Shipping & Transport, Govt. of India.

ANNEXURE 11.6

(Ref. Para 11.14.2)

Flood resistant sugarcane and Jute varieties

(a) *Sugarcane*

Varieties			Average yield tonnes/ha	Per cent sucrose in juice (%)	
				Oct-Dec. planting	Jan-March planting
Uttar Pradesh	CO 1007		58-62	12.1	17.2
	CO 1157		60-65	12.1	16.2
	CO.S 633		60-65	14.7	17.0
Bihar	B.O.43	(early)	47.5	—	12.9
	B.O. 76	(mid-early)	65.0	—	12.7
	CO.P.1	(mid-early)	50.0	—	12.5
	CO.P.2	(early)	55.0	—	12.5

(b) ***Jute***

Capsularies varieties (i) *JRC-321* Sown Feb-March and harvested after 120—130 days before flood with 2—3 tonnes per hectare fibre yield.

(ii) Local improved } Bidyasundari (Assam)
Fanduk (Bangladesh)

ANNEXURE 11.7

(Ref. Para 11.15.1)

Improved varieties of deep water paddy

(a) *Deep water paddy varieties*

State	Variety	Remarks
Andhra Pradesh	PLA 2	Stands 3—6′ water depth
Assam	EBI	,, 10—15′ ,,
	EB 2	,, 8—10′ ,,
	AR 1	,, 2—6′ ,,
	AR C. 353—148	,, 2—6′ ,,
	AR 614—25	,, 2—6′ ,,
Kerala	Ptb. 16	Deep water paddy
West Bengal	Hybrid 84 (Asr.108/1x Patnai—23)	Stands 6′ water depth
	Jaladhi—1	,, 3—M6′ ,,
	Jaladhi—2	,, 3—6′ ,,
Bihar	Br. 14	,, 6—8′ ,,
Uttar Pradesh	Jalmagna	,, 10—15′ ,,
	Jassuria	,, 6—8′ ,,

(b) *Flood resistant Varieties*

FR 13a, FR 43b, Madhukar, Chakia 59, PLA.4 ptb 15, CO 14.

XII COST AND BENEFITS

12.1. Introduction

Benefit-cost analysis may be conducted for different purposes and its content will vary according to the purpose for which it is intended. In the present context, it is used as a tool for determining the economic viability of projects in order to decide about their selection. When applied to "flood" projects, it helps to select not only the optimum level of adjustment to floods but also an optimum combination of measures for the purpose. Because benefits and costs stem from so many sources, a systematic procedure is required to make sure that all relevant streams are considered and evaluated properly.

12.2. Evolution of benefit-cost analysis

Flood protection works constructed prior to 1955 were very few and had been constructed by Zamindars, private individuals or Government in an *ad hoc* manner to take care of local problems. Naturally, therefore, the question of evolving a suitable methodology of benefit-cost analysis in the sense in which it is understood now did not arise. It was only after the disastrous floods of 1954 which highlighted the need for taking up flood protection works in planned manner and the subsequent decision to adopt benefit-cost ratio as a criterion that the details of the analysis received greater attention.

The erstwhile Ministry of Irrigation and Power in their communication of 12th October, 1955 to State Governments, prescribed a detailed format showing the manner in which benefits and cost should be analysed and evaluated for flood control projects to be submitted to the Centre for clearance. This format still continues to be adopted. Only the rates prescribed in respect of interest on capital and maintenance have been revised from time to time. Barring a few exceptions, indicated in the subsequent pragraphs, most of the States follow the procedures laid down in the above communication for submitting projects to the Centre.

12.3. The present methodology

12.3.1. *Costs*

The capital cost of a project is compiled by adding costs estimated to be incurred on such items as investigation and planning, land, building, works, tools and plants, work charged staff, maintenance during construction, contingency etc., as per established standards in the Irrigation and Flood Control Departments. From this an estimate of annual average cost is obtained by adding annual interest, depreciation and maintenance costs, each calculated at some prescribed percentage of total capital cost. The all-inclusive rate prescribed for this purpose has changed from time to time. It was 6 per cent to start with in 1955, raised to 9 per cent in 1968-69, and to 11 per cent in 1970. The latter comprised 6 per cent interest charges, 2 per cent depreciation and 3 per cent annual maintenance charges. The interest and maintenance rates were further revised in October 1973. The former was raised to 10 per cent so as to be in line with the rate applied in irrigation projects. Maintenance charges were revised upward to 5 per cent in case of anti-erosion works and 4 per cent in case of embankment and other works. This was in accordance with the recommendation of the Ministers' Committee on Floods and Flood Relief, 1972. Thus, the annual cost was recommended to be calculated at 16 per cent of the capital cost in the case of embankment and drainage schemes and 17 per cent in the case of anti-erosion and anti sea-erosion works. These rates are being adhered to since then. In the case of three States, namely, Orissa, Andhra Pradesh and Madhya Pradesh, cost figures sometimes include amortisation charges instead of depreciation charges.

12.3.2. *Benefits*

The procedures for estimating annual benefits are different for flood control, drainage and anti-erosion works. In the case of flood control works say embankments, the estimate of annual benefits is made by finding out the average monetary value of annual flood damages of few years before the construction of the project. In the case of Haryana and Uttar Pradesh, however, benefit is estimated by multiplying area affected by an assumed value of damage per hectare of Rs. 500 in Haryana and Rs. 750 and Rs. 1250 for unirrigated and irrigated lands respectively in Uttar Pradesh. From this, an estimate of the average annual damage after the construction of the project is supposed to be deducted. There is also provision for appropriate adjustments for the beneficial value of silt deposition, if any. The benefit takes into account expenditure on relief and rehabilitation, revenue remission, agricultural loans, etc. But this part is not followed in all States.

In the case of drainage schemes, benefit is estimated as monetary value of damages calculated on the basis of loss of yield of crops—total loss in areas subject to acute drainage congestion and partial in case of others. The area to be benefited is determined with reference to the maximum area ever suffered from drainage congestion. Benefit from anti-erosion schemes is determined by the value of land and assets thereon which might get eroded if the scheme is not implemented. This estimate is derived from the rate of erosion experienced in the past and assuming the same to continue in the future.

12.4. Social benefit-cost analysis

The first step in benefit-cost analysis consists of visualising some solution to the flood problem after identifying its nature and magnitude as precisely as possible and taking into account the associated technical, legal administrative and economic aspects. The maximum advantage from benefit-cost analysis is derived when a range of viable alternatives is taken into account the next step lies in identifying the items of benefits and costs of the proposed alternative, determining their quantities, selecting appropriate prices for evaluating them in terms of money and further processing them for making them comparable. All relevant sources of costs and benefits should be considered and evaluated properly so as to make the analysis as thorough as possible. What is a relevant source and how it is to be evaluated can be decided in the light of the overall approach and perspective towards the benefit-cost analysis i.e., whether we are looking at the project from the financial or the social angle. In the former case, only costs incurred and benefits derived by the project authorities are taken into account. In the latter case, costs incurred by the society as a whole are taken into account, similarly the benefits. It is now generally recognised that our approach towards benefit-cost analysis for the purpose of project selection and decision making (as distinct from financial control and budgeting) should be 'social' rather than financial or accounting. During our discussions with State Governments, several officers favoured adoption of social benefit-cost approach. The Government of Andhra Pradesh and Bihar forwarded to us copies of some exercise made by them in this regard. We also note that even at present, benefits from a flood control project are reckoned in terms of advantage derived from it by beneficiaries and not the financial return received by project authorities.

There are some difficulties that arise in case a full-fledged social benefit-cost analysis is applied now to flood control projects. These are associated primarily with the pricing of various items of cost and benefit. On the one hand several items in a social benefit-cost analysis such as the so-called intangibles do not have any market value; on the other, due to several distortions and imperfections of the market mechanism, which exist in our country, prices of a number of items including inputs like labour may not reflect society's valuations of final goods and services which is what is needed for a social benefit-cost analysis. The check list of cost items usually available with the authorities has been evolved mainly for the purpose of preparing project estimates using market prices. These include indirect taxes such as excise levies, sales taxes etc. and subsidies which, being transfer payments, should not form part of social cost of projects. Also, in a country like ours, wages paid to unskilled labourers are generally more than the social cost of such labour. Social benefit-cost analysis would, therefore, require additional information on the extent of indirect taxes, subsidies etc. on various inputs.

The concept of 'shadow' or accounting prices has been evolved to reflect the true social opportunity cost of using resources. However, there are intricate problems of estimation associated with shadow prices even at the conceptual level and the problems increase once an effort is made to apply them in specific areas. Moreover, the information required for the analysis is substantially more than what is available at the present moment. In addition, estimation of shadow prices would require specialised economic expertise of a high order which is not generally available in the irrigation and flood control departments both at the Centre and the States. Much organisational preparation is needed for determining shadow prices of cost and benefit items in different parts of the country before the social benefit-cost approach can be adopted in full.

In view of the above difficulties, we do not recommend the use of social benefit-cost approach for the time being. However, keeping in view the desirability of introducing it, after some time, we recommend that the authorities dealing with flood control and related water resources should give high priority to sponsor and encourage research in this field, take up certain projects for detailed study and initiate steps for creating economic cells both at the Central and the State levels.

12.5. Direct and indirect benefits

Benefits are sometimes classified into two categories—direct and indirect. Direct benefits refer to those produced on account of direct physical effects of projects such as reduction of damage to items coming in contact with flood waters *e.g.* crops, cattle, buildings and the contents thereof, public utilities etc. Benefits arising out of technological and economic linkages of the effects of a project are regarded as indirect *e.g.*, increased benefits of transportation (due to reduction in interruptions to traffic) or increase in agricultural productivity on account of flood control measures. These benefits may stem from or be induced by the direct benefits.

Replies from State Governments as well as central agencies indicate that the benefits taken into account for project formulation belong to the category of direct benefits only. Indirect benefits are not included because it has not been possible to quantify them so far. Desirability of considering these benefits has been suggested quite often by project promoters. The inclusion of such benefits is generally thought to increase the value of benefit-cost ratio and thereby help in getting clearance for more projects. Since indirect costs also enter into the estimates along with benefits, these tend to reduce or neutralise overall benefits. The possibility of some adverse effects due to implementation of a project cannot also be ruled out; for instance, sometimes an embankment may lead to increase in flooding upstream, downstream or on the unembanked side. Sometimes construction of a dam results in deterioration of river regime downstream due to the absence of flushing facilitated by floods. The net effect of all these factors on benefit-cost ratio may not always be to modify it. Whatever that be, there is no justification for neglecting the indirect effects altogether. These benefits and costs constitute an important aspect of project impact and can be considered for inclusion in benefit-cost analysis.

However, it may be extremely difficult to identify and quantify all the indirect benefits which may be attributable to flood control. It is obvious that all the new activities in the project area such as irrigation, roads, railways, schools, hospitals etc. which may follow the execution of a flood project, cannot be regarded as benefits of the project. The list should include only those which may be easily identified to be a logical consequence of the project. For example, control of floods by itself may bring about changes in cropping pattern, cropping intensity and per hectare productivity. Moreover, since flood control measures assure protection to agricultural land from the threat of inundation and flood losses, they may lead to greater farm investments and may improve agriculture in the area protected, eventually resulting in high yield and increased production. The additional production, if any, due to such improvements over the traditional level of production should also merit inclusion on the benefit side. However, while doing so, the additional costs of inputs such as fertilisers, irrigation, water, pesticides, etc. should be deducted to get an estimate of net benefits on account of floods. On the other hand, flood control projects in certain situations may tend to reduce land productivity. This may happen due to loss of fertilising silt, if any, and reduction of soil moisture which may be brought about by prevention of floods.

All such effects to the extent that they can be quantified at the time of formulation of a project should be included in the benefits. However, we know that the quantification of several of these benefits poses enormous problems. Given the present state of our knowledge, data and information, it is not possible to evaluate them through normal administrative agencies. Hence in such cases, the indirect effects should be listed and described in a qualitative manner. There may be situations in which these descriptions may turn out to be crucial for decision making.

As a result of the persistent efforts made by researchers it has been possible to devise means of quantifying several of the benefits and costs which were earlier supposed to defy quantification. Even with respect to the intangibles, some progress has been made in other countries in evolving procedures for measuring their effects. The authorities in charge of flood control and water resources development at the Centre and the States should take positive steps for encouraging and supporting techno-economic and socio-economic research for continuous improvement in the process of quantification of various indirect effects discussed earlier.

12.6. Cost estimation

12.6.1. *More realistic estimation*

The major source of difficulty in cost estimation is not the identification of cost items, but that of determining the quantum of each item including labour that will be needed. There are several examples which show how the costs as initially estimated at the time of formulation of a project do not provide a realistic estimate of costs actually incurred. Upward revision of costs due to factors other than changes in the price level is quite usual. As the Expert Committee on Rise in Costs of Irrigation and Multipurpose Projects (1973), has pointed out the most important reason for this, is lack of adequate investigation and surveys in the preparation of project estimates. Other reasons mentioned by the Committee are lack of appreciation of the role that a specialist in different disciplines may play in drawing up a scheme properly, inadequate attention paid to source and quality of available data, failure in visualising construction methods and procedures in advance, improper estimation of requirements for establishment, and building facilities etc. Moreover, as the Committee has pointed out, sometimes costs are under-estimated on account of pressure from various quarters so as to get a project cleared showing a favourable benefit-cost ratio. Other factors which could lead to increase in costs would be delay in land acquisition and delay in getting materials.

This underlines the need for thorough investigation before preparing the estimates of costs. Detailed guidelines in this respect should be worked out and prescribed. We note that certain guidelines for the minimum investigations to be done for formulation and submission of irrigation and hydro-electric projects were laid down and forwarded to State Governments by the CWPC in February 1972 which were further amended in December 1972 and July 1975. The Planning Commission has also issued guidelines for this purpose. We recommend that these guidelines should be followed and the prescribed investigations be conducted as thoroughly as possible. In addition, information on basic items such as up-to-date rates of wages and of materials, prices of equipments and machinery which are used for making cost estimates should be provided in the project report so as to facilitate scrutiny. For this purpose periodic economic survey may be conducted by the State flood control department and advantage may be taken of the finalised cost figures mentioned in recently completed projects.

In order to facilitate more realistic estimation of costs the CWC guidelines also give an idea of some norms in terms of percentages which may be taken into account for estimating certain costs (*See* Annexure 12.1). These percentages are said to have been worked out on the basis of experience. It is recommended that the experience of a number of recently completed flood control works be analysed and in the light of that, revised percentages may be worked out, till then, percentages mentioned in Annexure 12.1 may be used.

At the national level, as suggested by the Expert Committee on Rise in Cost of Irrigation and Multipurpose Projects, the Central Water Commission should have a cell for collection of data and preparation of construction cost indices for major items for work of river valley projects.

12.6.2. *Additional capital works*

A significant aspect of flood control measures especially embankments is the cost subsequently incurred on works such as anti-erosion measures like spurs and revetments undertaken for stabilising the same benefits. Expenditure on such additional capital works, when incurred for several years, could easily amount to a significant proportion of the original capital cost. For example, in the case of the Puthimari embankment in Assam, Rs. 231 lakhs have been incurred on construction of the embankments along with their subsequent raising and strengthening, while the expenditure on anti-erosion measures undertaken in different years amounted to Rs. 47 lakhs (or 20 per cent) upto 1977-78. The proportion would be even higher in a more troublesome river. For example, in the case of the Kosi river, known for frequently changing its course, the sum spent on additional capital works for the safety of the embankments like construction of spurs and revetments has amounted to Rs. 1,900 lakhs by 1977-78, which has been more than the amount of Rs. 800 lakhs incurred on the construction of the embankments as such. Schemes for protecting embankments against subsequent attacks by the river have been undertaken in several other cases also. Rivers generally meander, a few have a tendency to shift their courses. Hence, while embanking them, it is to be expected that the embankments, in some cases, may come under attack, necessitating expenditure of the type mentioned above. As per present practice, provision for such works is not made in the original cost estimates while working out the B/C ratio. The quantum of this expenditure would vary from area to area depending upon river characteristics and other relevant factors. It is, therefore, recommended that government should get this matter examined by a technical committee and prescribe suitable norms in the light of considerable experience already gained in the country so that wherever relevant, estimates of these costs are also included in the benefit cost exercise, at the time of project formulation. It may be mentioned that costs estimated to be incurred on these future works are to be included only for computing the B/C ratio and should not be included in the original project estimates.

12.6.3. *Cost revision*

An aspect of the benefit-cost analysis to which we would like to draw attention is the upward revision of the cost estimates of projects, especially the bigger ones. It is expected that a more effective system of cost and benefit analysis would reduce cost revisions. However, even then revisions may not be ruled out completely. When the costs of projects increase, it affects the benefit-cost ratio. It is, therefore, necessary that the procedure laid down in the Accounts Manual for cost revision should be followed and revised benefit-cost ratio worked out.

12.6.4. *Time-phasing of cost estimates*

The costs of most of the projects are usually spread over a number of years. However, information on construction schedule and time phasing of estimates is seldom provided. This is one of the serious deficiencies of the current practice. It commits the mistake of adding the costs incurred in different years, ignoring the view that the money values of different years should not be added directly on account of considerations related to the time value of money to be discussed more fully in para 12.10.2. In other words, the rate of interest during construction of the projects is not taken into account while making an estimate of capital cost. As a result the cost figures remain the same even if the completion of the project is delayed. In the absence of this information, it is not possible to make a realistic evaluation of costs which can be compared with benefits to judge the economic viability of the project. Hence it is recommended that an yearwise estimate of capital costs to be incurred in different years should be worked out, after taking into account the time needed for completing the work.

12.6.5. *Annualising cost estimates*

As already indicated, the total capital cost is converted into annual figures to arrive at an estimate of annual capital cost spread over the life of the project. The annuity method followed is one of simple interest (at 10 per cent) and of straight line depreciation (at 2 per cent per annum). This method results in higher than economically justified figures of annual capital costs. The annuity method should be such that the sum of present value of the annual figures should just equal the total capital cost from which the annual figures are derived. However, the sum of the present worth of the annual figures as computed now works out to be greater than the original project cost. For example, let the total cost of a project be Rs. 100,000 which gives a figure of Rs. 12,000 for interest and depreciation for the next 50 years. Now the sum of present value of annual series of Rs. 12,000 for 50 years at 10 per cent rate of interest comes to Rs. 118,978. In other words, the costs get over-estimated to the extent of Rs. 18,978. The problem arises because of the use of simple interest rate instead of the compound interest rate which is considered more appropriate for an economic analysis of projects. As for depreciation, a better technique would be sinking fund method of depreciation which is also based on the compound interest principle. According to it uniform annual amounts are paid into a sinking fund where interest is compounded annually. At the end of the assumed life of the work, the amount accumulated equals the original capital cost. In view of the interest that is earned, the amount of depreciation charged is somewhat less than that under the straight line method. The uniform annual amount consisting of interest and depreciation (as per sinking fund method) is worked out by multiplying capital cost with the capital recovery factor. (Sometimes, the term amortization has been used to denote this concept). However, as argued later on in para 12.10.2 the entire exercise for deriving annual estimates is unnecessary and should be dispensed with. Both annual interest and depreciation are automatically taken care of in the process of determining the present worth of costs through discounting.

12.6.6. *Maintenance cost*

Maintenance cost is assumed at a uniform rate of 4 to 5 per cent of the capital cost. It is realised that such cost cannot be a uniform percentage of capital cost in all areas and for all projects but would vary according to the nature of the work proposed and the behaviour of the river. As pointed out in Chapter XVII it would be better to determine such costs with reference to length of embankment or other physical dimension of the structures for preparing annual maintenance budget. For purpose of project preparation, however, it would be easier to work on percentage basis. While calculating percentages one should take into account not the whole of the capiatl cost but only the cost of works, *i.e.*, capital cost minus the cost of land, preliminary expenses special T & P etc., as has been clearly laid down in ISI Standard of 1968 and CWC Guideline of July 1976. This is not being followed. We recommend that these adjustments in capital cost be made before applying percentages for determining maintenance cost.

12.6.7. *Price changes and cost estimates*

The cost estimates for different years during the entire life of the project have traditionally been prepared on the basis of current prices. Consequently no provision for future increase in prices during the period of execution of the project is made. However, a plea is often made that the estimates of cost to be incurred in later years should be appropriately adjusted to take care of price rises in future. We have looked into this issue and find no need for any change in the existing procedure in so far as the benefit-cost analysis is concerned. For one thing, this is quite unnecessary for judging the viability of projects because the benefit-cost exercise is done under the assumption of constant prices. The intention is to judge the viability of a project in 'real' terms. Prices used in the analysis should reflect 'real' cost and 'real' benefits and, therefore, it is assumed that the price level as a whole remains constant over the life of the project. Moreover, a change in the general price level in so far as it affects both costs and benefits in the same direction will not make much difference to the benefit-cost ratio. Besides, no government worth its credibility will be willing to provide for a price increase in cost estimation because this will be in conflict with the government's declared policy of maintaining price stability. Taking all relevant factors into account, we recommend that the present practice of estimating costs with respect to the current price level be continued.

So far, we have been concerned with expected changes in the general price level. However, sometimes changes in relative prices may be expected on account of future changes in demand and supply of specific commodities both inputs and outputs. For example, the price of cement may be expected to rise *vis-a-vis* those of other commodities. But it is extremely difficult to make correct estimates of such changes. There is no agency in our country which has the responsibility of releasing firm estimates of such changes in prices of specific commodities. Hence, this consideration may also be ignored unless there is a very strong case for taking it into account in specific cases.

12.6.8. *Cost allocation of multi-purpose projects*

Another problem associated with cost-benefit analysis is one of estimating the share of flood control in the cost of a multipurpose project. The problem assumes critical significance in case the costs and benefits of a project are spread over more than one State which is quite often the case In that event an objective basis of cost allocation is needed to avoid inter-State or inter-group disputes based on subjective assessment of cost incidence.

There are some examples of storage reservoirs involving flood control and they follow different methodology. According to the Damodar Valley Corporation Act of 1948, the joint costs are allocated to different purposes in proportion to the expenditure which could have been incurred in constructing a separate structure solely for that object less any amount which is solely attributable to the object. In the case of the Hirakud Project, the same principle of alternative justifiable expenditure method was originally followed and accordingly the allocation of the costs of storage capacities between flood control, irrigation and power was in the ratio of 38:20:42. Later on, in 1952 this was changed in favour of a new method based on the ultimate utility of water for various purposes. Flood control as a separate purpose was eliminated. Subsequently, at seminar organised by the Government of India in 1961, it was decided that joint costs be allocated to various purposes in proportion to the reservoir capacity or quantity of water utilised for each purpose. In the light of this, flood control was to share 25 per cent of the reservoir cost on account of the consideration that the reservoir operates for flood control for three months in a year. In the case of Kosi Project in Bihar, the cost of barrage is deemed to be a common facility for flood control and irrigation and its cost is divided equally between them. In the case of Rengali Project in Orissa, cost of Stage I of works had been allocated equally between flood control and irrigation since the same storage capacity could be used equally for both the functions. From these practices, it is clear that broadly speaking, two methods have been in use in our country—one on the basis of alternative justifiable expenditure and the other on the basis of use of the common facility for different purposes.

In April 1967, the Government of India, in the then Ministry of Irrigation and Power, recommended the adoption of the 'facilities used' method for the allocation of joint costs of multipurpose river valley projects. This method is specific to storage reservoirs. It, therefore, leaves open the question of cost allocation in other cases. Even in this case, it fails to throw any light on a basic principle of joint cost allocation, namely no purpose should be assigned costs any greater than would be incurred if that function was to be supplied by the most economic alternative single-purpose project. The alternative single-purpose project establishes the maximum which can be charged for any one purpose. For example, it is not justifiable to allocate to the flood control component a cost more than that of protecting the same area and to the same extent by an alternative method.

In a number of other countries, a somewhat different method known as the method of separable costs-remaining benefits is being followed. This method takes into account the principle cited above as well as another basic principle of joint cost allocation namely the assigned costs of any purpose should not exceed the value of its benefits. Accordingly, the maximum justifiable expenditure for any purpose is given by the value of its benefits or alternative costs whichever may be less. Alternative costs are the costs of the most economic single purpose project which can provide the same benefit and in the same area as the multi-purpose project. The alternative project may be located in a different area and may be of a different nature. The method is illustrated in Annexure 12.2. This method appears little more complex than the earlier method but we should realise that the problem of joint cost allocation arises generally in the case of costly projects running into hundreds of crores and staffed by qualified personnel. Such projects, therefore, should be in a position to work out more realistic estimates of costs. The complexities arise on account of the need to estimate alternative costs. But as we know a discussion of alternatives must precede any scientific planning including benefit-cost analysis, whether the project is single purpose or multi-purpose. Hence this consideration by itself does not impose any extra burden on the analyst. We, therefore, recommend that the method of separable cost-remaining benefits may also be taken into account for allocating costs of multi-purpose projects.

12.7. Assessment of benefits

12.7.1 *Quality of damage data*

The assessment of benefits from most of the water resources projects is generally considered to be more difficult than that of costs. This is especially true of flood control projects. There has been a wide-spread feeling conveyed to us through replies to our questionnaire and in discussions that the assessment of benefits from flood control projects has remained unsatisfactory. Part of the difficulties arise on account of the very complex nature of benefits and not much can be done to improve that under the present circumstances. However, part of the difficulty can be removed by adopting a better system of reporting and evaluation. The benefits from flood control projects mostly consist of an estimate of flood damage prevented. Therefore, substantial improvement in the assessment of benefits can be brought about only if the assessment of damage is made in a satisfactory manner.

The methodology of damage assessment which is in vogue in the country has several shortcomings which have been pointed out in our chapter on 'Methodology of Damage Assessment'. A number of recommendations for bringing about improvements have been made there and we would repeat that these be implemented.

12.7.2. *Estimate of areas and damages*

A first and important step in deriving an estimate of benefits from a flood control project lies in making an assessment of the area to be benefited from such a project. This should generally be derived with the help of contour maps. It is, however seen that this is not done and that the delineation of the area to be protected is quite often made in an arbitrary manner. It is understood that contour maps are not provided along with project reports in support of the claims of the area estimated to be protected. Also, contour maps for all areas are not available. In that case, flood marks should be used for the purpose. Thus, we recommend that an estimate of the area to be protected should be made with respect to the design flood for which project is prepared either with the help of contour maps in case they are available or with reference to the area flooded in some specific flood years in the past. Low lying areas which are always submerged should be excluded. For anti-erosion works, the extent of the probable meander should be considered for assessing the area protected.

The next step lies in making an assessment of the benefit in monetary terms in the area to be protected as delineated above. For this purpose, according to the prescribed guidelines, figures on flood damages are to be procured. However, such figures are usually available at the level of districts and blocks and not at the level of a specified area in a particular basin or sub-basin selected for flood control. A recommendation for bringing out flood damage data with respect to basins and sub-basins has been made in Chapter IX. However, so long as basin-wise data are not available it is recommended that figures at the district or the block level should be apportioned on a *pro rata* basis with respect to the area flooded.

While most of the States follow the prescribed guidelines for estimating benefits with reference to data on flood damages of past few years provided by the revenue authorities of the area, States like Uttar Pradesh and Haryana assume a fixed value of damage per hectare of area affected. For example in Uttar Pradesh estimate of benefit from a flood control project is made by multiplying the benefited area with a flat rate of Rs. 750 per hectare for non-irrigated area and Rs. 1250 per hectare for irrigated area. In Haryana 50 per cent of the benefited area is assumed as cropped for which the loss is calculated at Rs. 500 per hectare. During our discussions with the concerned State Governments, we found that there was no scientific basis for these figures. There is also an implicit assumption that the entire flood-prone area suffers from yearly damage to the extent of the assumed per hectare figure and that damage everywhere in the affected area is uniform. Such procedures are clearly arbitrary and should be discontinued. It is recommended that these States may fall in line with the other States.

12.7.3. *Determining yearly average damage*

There is considerable diversity in the use of damage data for estimating the average annual benefits. In some cases, flood protection works are taken up in the wake of a high flood. Sometimes, as in Assam, the damage data of only that year which could be a year of maximum damage is taken into account and the same is regarded as average damage. In some cases the number of years taken into account for determining the average vary from 5 to 10 recent years, as in West Bengal. Procedures like these may lead to over-estimation and may not give a correct idea of the average annual damage.

Rare floods of a rare frequency have only a slight influence on the value of average annual damage. But the inclusion of the damage data of a severe flood year, say of 100 years' flood frequency in a series containing the preceding 5 or 10 years' data leads to a marked over-estimation of the average damage figures. A correct idea of the average can be gained only if figures based on long periods are used, the longer the period, the more reliable the average. However, it can be said that the longer the series the more unreliable the earlier estimates because of changes in prices, land use, cropping pattern, developmental activities, etc. Floods of a similar type of magnitude can produce a different order of damage today, as compared to what they could have done 20 years ago. This problem can, however, be taken care of without much difficulty. Changes in prices can, as explained later, be taken care of by evaluation in terms of current year's prices and changes in productivity, where significant, adjusted with the help of standard methods. Considering all factors, we recommend that damage-data for 15 to 20 years should be used for deriving the average annual damage. We understand that data for this length are available in unpublished form with the revenue authorities.

Even then, in some cases it may so happen that the damage data are not available for the requisite number of years. On the other hand, hydrological data may be available for an adequate number of years to enable flood frequency studies. In such cases, the limited number of years of flood damages could be used to approximately assess the likely benefit by taking recourse to the additional available information from the flood frequency studies.

12.7.4 *Transfer payments*

The prescribed guidelines provide for the inclusion of several transfer payments such as expenditure on relief and rehabilitation, agriculture and other loans and remission of land revenues in the benefits. This is wrong because it results in double counting. Revenue remission does not result in any additional loss to people. It simply compensates them partially for the loss already taken place. It may result in loss of revenue to the Government. The benefit-cost analysis, however, should take into account the benefit to the community as a whole and not to the Government or an individual. Similar is the case with expenditure on gratuitous relief and rehabilitation. When such expenditure is made, people get compensated for the loss that they have already incurred. This does not imply any additional loss. If we include expenditure on relief and rehabilitation, then it is necessary that losses of people to the extent they are compensated by expenditure on relief, rehabilitation etc., are reduced, otherwise, there will be double counting. The case for excluding agricultural loans etc., which are recoverable items is too obvious to require any elaboration. Hence we recommend that the present guideline be amended by deleting the columns for relief, rehabilitation, loans and remission of land revenue.

It could be that part of the relief expenditure incurred by government is on medical measures or on building temporary habitation facilities such as tents and huts which represent loss to society and should be taken into account. Expenditure on rescue operations also belong to this category. However, separate figures for these are not available. In fact quite often separate figures on even total of relief expenditure on flood are not available and therefore not provided in project reports. The Revenue Authorities of some States with whom we discussed the matter did not consider it feasible to provide this information separately. We would, therefore, like the matter to be analysed through some case studies so as to know the full details of the composition of total relief expenditure.

12.7.5. *Additional area made available by the project.*

The present mode of working out benefits from a project is by assessing the available data on the extent of flood damages of past years. An important direct benefit which tends to be ignored in this process is the increase in area which may become available for cultivation and for other economic uses. For example, hill torrents emerging from the foothils into the plains keep changing their courses, as a result of which a wide area goes under the river bed and berm and is rendered unsuitable for cultivation. As for example, the river Chenab spreads over a large width of 10 to 12 km. near Akhnoor. Kosi reported to have shifted its course several times before it was embanked and rendered vast tracts of lands uncultivable. As no crop is grown on such areas, they do not figure in the calculation. Similarly, the tail command of a channel may not be growing any kharif crop on account of the flood problem. In case the flood problem is resolved, the area may have a potential for development of cultivation. Accordingly we recommend that in such cases the benefits on account of increased area being made available should be included as an additional direct benefit. The assessment of this benefit should be made with respect to the productivity and other attributes of land of similar type in the area and not with respect to relatively more developed or more fertile land. With respect to land thus made available for cultivation, the annual benefit should be assessed in terms of the value of net agricultural production from this additional land. With respect to land to be used for non-agricultural purposes, the value of land may be assessed according to prices in the locality and added to the other benefits.

12.7.6 *Effect of silt etc. on agricultural production*

There is a general impression that silt has a fertilising value which results in bumper crops. We could not, however, get any supporting data on the ground that such data are not available from official sources. In this context it is noticed that the guidelines currently prescribed by the Government of India provide for taking into account the loss due to fertilising value of silt. The method of determining this value has not, however, been indicated. Presumably, on account of this, most of the State Governments tend to ignore this consideration in project reports and even those who take this into account use some *ad hoc* lump-sum figures without giving any justification.

Whether and to what extent, the silt brought by floods has any fertilising value is a debatable point. There is no sufficient empirical evidence for holding any firm view. The issue gets complicated because silt is inextricably mixed up with changes in soil moisture, ground water level and physical condition of soil brought about by floods. Inundation of flood plains is also known to wipe out soil-borne pests like rodents and insects. Similarly, prolonged inundation inhibits weed growth. On the other hand, such inundation may not make the area free in time for rabi cultivation. Also sometimes, there may be deposition of sand instead of silt.

The assessment of fertilising value of silt, if there be any, will obviously vary from area to area, depending upon its quality an recurrence. Hence no general guideline can be prescribed Wherever, relevant, the effect of silt may be determined at the time of the formulation of a project by comparing data on the yield of a representative sample of flood affected farms with similar farms in nearby flood-free areas (*i.e.* with and without approach) for the preceding few years. The difference between the two sets of yields, if any, may be regarded as the value of fertilising silt and inundation.

12.7.7. *Post-project damages*

The prescribed guidelines provide for the adjustment of damages that may continue to take place even after construction of flood control schemes. It, however, appears that most of the States ignore this consideration and assume that damages after the works would be nil. This is not justified because the area protected may continue to suffer damages at least in some situations. For example, in Jammu and Kashmir, the area protected by the embankments of river Jhelum gets flooded due to several unembanked tributaries and nalas which join the Jhelum. Sometimes damage may be produced by both flood and drainage congestion. Some problem of drainage congestion may remain even after protection is provided against flood. It is, therefore, recommended that this aspect should also be dealt with in project formulation, and especially examined during scrutiny and sanction.

12.7.8. *Land values*

There is sometimes a tendency to count benefit of flood control measures both in terms of damage prevented as also rise in land values. This does not apear to be justified as the value of land being the capitalised value of income from it, and the income being the yield from land, the two are necessarily correlated. Anything that increases income from land will automatically increase the value of land. Thus, benefits should be reckoned either in terms of increase in income which is measured by damage prevented or in terms of rise in the value of land but not both, otherwise there is bound to be double counting of the same benefit.

Of the two, land values could be regarded theoretically the better because they reflect the effect of changes in productivity as well as intangible benefits like sense of security on account of flood control measures. However, land values are affected by several other considerations also, such as development of roads and irrigation which may be taking place concurrently, as such, it is not possible to assess the change in the land value attributable to flood protection.

12.8. Analysis for inter-related projects.

Quite often the same benefits are taken into account to justify different parts of an interrelated scheme, each part processed as a separate scheme and sometimes at a different time. For example, there could be a scheme for an embankment followed by a scheme for drainage spurs etc., all intended to protect the same area, here, there is a possibility of making use of the same benefit figures. Again, when there are overlapping areas between two or three projects there could be a possibility of counting the benefit of the common area more than once. Similarly, a number of schemes may be taken up in combination with each other in order to tackle a given problem as is implied under the comprehensive approach to flood control planning. Thus, sometimes the same benefit figures may be used to justify different schemes of the kind mentioned, this defeats the purpose of the benefit-cost exercise and should be viewed with concern.

Benefit-cost analysis for inter-related projects should be prepared by making fresh assessment of benefits from the combined project and not by adding of benefits of separate projects. At the same time individual justification for each project should be checked to ensure that every scheme is viable. While preparing a master plan|comprehensive plan, some idea of the overall benefit and cost in a broad sense may be given so that one can form an impression of the worth of the plan as a whole.

12.9. Risks and uncertainties

There are several types of risks and uncertainties associated with projects in general and water resource projects in particular. Hence an assessment of benefit cannot be made with certainty. Even floods of different frequencies cannot be forecast with accuracy. The behaviour of river remains unknown and unpredictable. There are uncertainties with regard to several aspects such as life-span of a project, silt benefit, damage that may take place after completion, time required for construction and so on. The possibility of breaches and over-topping too cannot be ruled out. There is no provision for taking care of such risks and uncertainties in the existing guidelines. In recent years the technique of sensitivity analysis carried under alternative set of assumptions has been developed for taking risks into account. We recommend that such an analysis should be conducted for large-sized projects costing more than Rs. 50 crores.

12.10. Comparing costs and benefits.

12.10.1. It is necessary that benefits and costs should be expressed in comparable terms. This comparability is not ensure under the present practice because (i) costs and benefits are not expressed in terms of the same year's prices and (ii) they ignore the question of time value of money.

12.10.2 To elaborate the first point, while costs are estimated at current prices benefits, being regarded as the average of flood damage are calculated at the respective current prices of past several years. As an example suppose damage figures from 1965 onwards are to be used for estimating the average damage. In this calculation, damage for the year 1965 would have been assessed in terms of 1965 prices, that for the year 1966 in terms of 1966 prices and so on for different years. This procedure is defective and should be changed. In order to make the two figures comparable, we recommended that flood damage data of different years should be evaluated in terms of prices of the base year which are used for cost estimation. This may be done with the help of an appropriate price index, figures of which are now available over a period of time. The base year used for benefit-cost analysis, should invariably be mentioned in the project report.

12.10.3 Coming to the second point, costs and benefits of almost every flood control project are spread over a number of years. Costs are incurred not only during the period of construction but also subsequently on account of operation and maintenance and sometimes for major renovation and additions such as construction of spurs, revetments etc. Similarly benefits keep on accruing so long as a project is alive. Moreover, the time stream of costs an benefits are also different. We are aware that the value of money changes over time on account of the phenomenon of interest rate. In other words, the value of Rs. 100 today will be different from that of Rs. 100 after some time, say a year. At 10 per cent rate of interest, the real value of Rs. 100 will be Rs. 110 after one year. As a result, strictly speaking the cost and benefit figures of different years as usually given in an unprocessed form are not comparable. Hence an addition of unprocessed data on costs and benefits of different years cannot enable us to say whether the sum total of benefits is more than, equal to or less than the sum total of costs.

Thus a method is required for making these figures comparable. This method should be such as could also take care of both uniform and non-uniform streams of costs and benefits in different years. The technique of discounting meets these requirements and is being increasingly used in the world including our own country.

With the help of a given interest rate, cost and benefit figures of different years are recomputed to get their equivalent amounts with respect to a particular year. For example, at 10 per cent interest rate, Rs. 110|- after one year will be made equivalent to Rs. 100/- today and *vice- versa.* The figures can be either compounded to the last year of the project or discounted to the first year, both will give the same result being two sides of the same coin. The established convention is in favour of discounting, because it results in the present worth of all future money values, and as such, is considered more suitable from the point of view of making comparative evaluation of several types of projects which may be under consideration at the same time. This technique, being based on compound interest formula is easy to understand and apply. The availability of standard discounting tables (a sample of which is given in Annexure 12.4) has further simplified its application. We feel that without this minimum exercise, figures of total costs and benefits of projects having life span of more than one year would give misleading information.

The methodology is explained with four examples in Annexure 12.3. It will be noticed that, according to the present methodology the benefit-cost ratio remains constant irrespective of the time schedule of construction, when calculated by the proposed mtehod the ratio goes down progressively as the period of completion is increased. The examples also show that the ratio calculated by the proposed method could be higher as well as lower than that calculated by the present method depending upon the period of construction. The proposed methodology, in contrast to the present one, places a premium on early completion of projects and penalise those whose completion is delayed. It is always desirable to complete projects within the shortest possible time. This consideration, therefore, provides another reason for adoption of the proposed methodology.

We therefore, recommend that in order to evaluate a project, its benefits and costs of different years should be discounted at the prescribed interest rate and the benefit-cost ratio computed.

12.11 *Safeguard to ensure reliability of estimates*

As can be seen from the foregoing, there is scope for costs to be underestimated and benefits over-estimated. The suggestions given earlier, if implemented, are expected to improve the situation to a certain extent. These, by themselves, however, would not provide adequate safeguards against deliberate attempts to underestimate costs and overestimate benefits made under local pressures. The scope for this is provided by the fact that, by the very nature of things, a fool-proof system of universal application connot be indicated because physical and economic situation varies from place to place. An obvious remedy is to apply the well tried system of checks and balances. Significant improvement in the quality of estimates can be brought about only when estimates of benefits and costs are checked even on a sample basis by some agencies independent of the influence of and outside the fraternity of the concerned executive bodies. The need for giving this task to independent agencies 'staffed by personnel who clearly understand the purposes of benefit cost analysis and who are trained to canvass the full range of alternatives' has been suggested by a recent United Nations Guidelines for Flood Loss Prevention and Management. In order to ensure greater reliability of the benefit cost figures we recommend that the Planning Commission|Department should get some of the projects examined by independent outside agencies such as techno-economic research and consultancy organisations and draw the attention of the executive agencies towards discrepancies, if any, for initiating corrective measures on their part.

ANNEXURE 12.1

Reference—Paragraph 12.6.1

Norms for estimating certain cost items—worked out by Central Water Commission

Items	*Norms*
1. Preliminary expenses	1% or more of cost of I-works. In case of big projects costing more than Rs. 30 crores it could be up to 5%.
2. Cost of buildings	3% to 5% of I-works.
3. Miscellaneous	4% of the cost of I-works.
4. Maintenance during construction	1% of the cost of I-works less A—preliminary, B—Land and Q—special T and P.
5. Losses on stock	0·25% of the cost of I-works less A—preliminary, B—land and Q—special T & P.
6. Establishment (for works let out on contract)	8 to 10% for concentrated works and 10 to 12% for scattered works.
7. Establishment (for works done departmentally)	15%
8. T and P	1% of the cost of I-works
9. Audit and account charges	1% of the cost of I-works
10. Abatement of land revenue	Either at 5% of land cost or 20 times of annual revenue lost.

Source : Government of India : Central Water Commission—Broad Guidelines for Preparation of Project Estimates for Major Irrigation and Multipurpose Projects—July 1976.

सत्यमेव जयते

ANNEXURE 12.2

Reference—Paragraph 12.6.8

Joint-cost allocation for a multipurpose river valley project, using 'separable costs—Remaining benefits method—an illustrative example

(Rs. in lakhs)

Item/year	Purpose			
	Flood control	irrigation	power	total
1	2	3	4	5
Part I—Basic information				
1. Life of the project	100 years			
2. Discount rate	10 per cent			
3. Period of construction	3 years for flood control 4 years for power 5 years for irrigation			
4. Total cost				
Ist year				160
2nd year				260
3rd year				320
4th year				210
5th year				150
Total				1100
Present worth				(837·33)
5. Separable costs				
Ist year	15	45	25	85
2nd year	50	80	60	190
3rd year	35	115	80	230
4th year		90	55	145
5th year		70	..	70
Total	100	400	220	720
Present worth	(81·26)	(298·36)	(170·00)	(549·62)
6. Alternative costs				
Ist year	125	75	50	250
2nd year	200	170	130	500
3rd year	50	200	150	400
4th year		120	80	200
5th year		150		150
Total	375	715	410	1500
Present worth	(316·50)	(534·04)	(320·24)	(1170·78)
7. Benefits—annual average				
Flood control (4th to 100 yrs.)	50·30			
Irrigation (6th to 100 yrs.)		75·10		
Power (5th to 100 year.)			6090	
Total	4879·1	7209·6	5785·5	17874·2
Present worth	(377·87)	(466·26)	(415·91)	(1260·04)
Part—II Joint cost allocation (all values in present worth)				
1. Cost to be allocated				837·33
2. Benefits (up to 100th year)	377·87	466·26	415·91	1260·04
3. Alternative costs	316·50	534·04	320·24	1770·78
4. Justifiable expenditure (lesser of 2 & 3)	316·50	466·26	320·24	1103·00
5. Separable costs	81·26	298·36	170·00	549·62
6. Remaining justifiable expenditure (4—5)	235·24	167·90	150·24	553·38
7. Percentage distribution of 6	42·51%	30·34%	27·15%	100%
8. Remaining joint costs (1—5)				287·71
9. Remaining cost distributed as per (7)	122·31	87·29	78·11	287·71
10. Total costs allocated (5+9)	203·57	385·65	248·11	837·33

ANNEXURE 12.3

Reference—Paragraph 12.10.3

Examples illustrating use of discounting method

Example 1

Assumptions

Life of project—52 years

Rate of interest—10 per cent

Years of completion—2 years

(Amount in Rupees)

Year	Cost	Benefit	Discounting (or present worth) factor	Present worth Costs (2x4)	Present worth Benefits (3x4)
1	2	3	4	5	6
1 year	60,000		0.9091	54546	
2 year	40,000		0.8265	33060	
3 year	4,000	20,000	for uniform series from 3rd to 52nd year	32770	163850
3 year	4,000	20,000			
3 year	4,000	20,000			
3 year	4,000	20,000			
52 year	4,000	20,000	8.1925*		
Total .				120376	163850

सत्यमेव जयते

NOTES : B/C ratio as per prevailing methodology $= \frac{20,000}{16,000} = 1.25$

B/C ratio as per proposed methodology $= \frac{163850}{120376} = 1.36$

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*The discounting factors for intervening years (like 3rd to 52nd year in this example) are computed from table of discounting factors of the type given in column 3 of Annexure 12.4. First the uniform payment series factor (UPSF) up to 52nd year is noted (i.e. 9.9280) from which the UPSF for up to 2nd year (i.e. 1.7355) is deducted to get UPSF for the period from 3rd to 52nd year (i.e. 8.1925). The same method is followed in the following three examples also.

ANNEXURE 12.3 (*Contd.*)

examples illustrating use of discounting method

Example 2

Assumptions

Life of project—55 years

Rate of interest—10 per cent

Years of completion— 5 years

(Amount in Rupees)

Year	Cost	Benefit	Discounting (or present worth) factor	Present worth	
				Costs (2x4)	Benefits (3x4)
1	2	3	4	5	6
1	20,000		0.9091	18182	
2	20,000		0.8265	16530	
3	20,000		0.7513	15026	
4	20,000		0.6830	13660	
5	20,000		0.6209	12418	
6	4,000	20,000	(for uniform series from 6th to 55th year)		
7	4,000	20,000			
8	,,	,,			
9	,,	,,	6.1563	24625	123126
10	,,	,,			
55	,,	,,			
Total				100441	123126

सत्यमेव जयते

B/C ratio as per present methodology = $\frac{20,000}{16,000}$ = 1.25

B/C ratio as per proposed methodology = $\frac{123126}{100441}$ = 1.23

ANNEXURE 12.3 *(Contd.)*

Examples illustrating use of discounting method

Example 3

Assumptions

Life of project— 60 years

Rate of interest— 10 per cent

Years of completion— 10 years

(Amount in Rupees)

Year	Cost	Benefit	Discounting or present worth factor	Present worth	
				Cost (2x4)	Benefis (3x4)
1	2	3	4	5	
1	10,000		0.9091	9091	
2	10,000		0.8265	8265	
3	10,000		0.7513	7513	
4	10,000		0.6830	6830	
5	10,000		0.6209	6209	
6	10,000		0.5645	5645	
7	10,000		0.5132	5132	
8	10,000		0.4665	4665	
9	10,000		0.4241	4241	
10	10,000		0.3856	3856	
11	4,000	20,000	(for uniform series from 11th to 60th year)		
12	4,000	20,000			
..	,,	,,			
..	,,	,,			
60	4,000	20,000	3.8226	15290	76452
Total				76737	76452

सत्यमेव जयते

B/C ratio as per present methodology $= \frac{20,000}{16,000} = 1.25$

B/C ratio as per proposed methodology $= \frac{76452}{76737} = 0.995$

ANNEXURE 12.3 (*Contd.*)

Examples illustrating use of discounting method

Example 4

Assumptions

Life of project—65 years
Rate of interest—10 per cent
Years of completion—15 years

(Amount in rurpees)

Year	Cost	Benefit	Discounting (or present worth) factor	Present worth	
				Cost (2x4)	Benefit (3x4)
1	2	3	4	5	6
1	7,000		0·9091	6364	
2	7,000		0.8265	5786	
3	7,000		0·7513	5259	
4	7,000		0·6830	4781	
5	7,000		0·6209	4346	
6	7,000		0·5645	3952	
7	7,000		0·5132	3592	
8	**7,000**		**0.4665**	**3266**	
9	7,000		0·4241	2969	
10	7,000		0·3856	2699	
11	6,000		0·3505	2103	
12	6,000		0·3186	1912	
13	6,000		0·2897	1738	
14	6,000		0·2633	1580	
15	6,000		0·2394	1436	
16	4,000	20,000	(For uniform series from 16th to 65th year)		
..	,,	,,			
..	,,	,,			
.	,,	,,			
65	4,000	20,000	2·3735	9494	47470
Total				61277	47470

B/C ratio as per prevailing methodology $= \frac{20,000}{16,000} = 1{\cdot}25$

B/C ratio as per proposed methodology $= \frac{47470}{61277} = 0{\cdot}77$

सत्यमेव जयते

ANNEXURE 12.4

Reference—Para 12·10·3

Discounting factors for 10% interest rate

Number of years	Single payment present worth factor	Uniform payment series present worth factor
1	2	3
1	0·90909	0·90909
2	0·82645	1·73554
3	0·75131	2·48685
4	0·68301	3·16987
5	0·62092	3·79079
6	0·56447	4·35526
7	0·51316	4·86842
8	0·46651	5·33493
9	0·42410	5·75902
10	0·38554	6·14457
11	0·35049	6·49506
12	0·31863	6·81369
13	0·28966	7·10336
14	0·26333	7·36669
15	0·23939	7·60608
16	0·21763	7·82371
17	0·19784	8·02155
18	0·17986	8·20141
19	0·16351	8·36492
20	0·14864	8·51356
25	0·09230	9·07704
30	0·05731	9·42691
35	0·03558	9·64416
40	0·02209	9·77905
45	0·01372	9·86281
50	0·00852	9·91481
55	0·00529	9·94711
60	0·00328	9·96716
70	0·00127	9·98734
80	0·00049	9·99512
90	0·00019	9·99812
100	0·00007	9·99927

सत्यमेव जयते

The following formulae may be used for calculating discounting factors for any interest rate.

(i) Single payment present worth factor $= \dfrac{1}{(1+i)^n}$

(ii) Uniform payment series present worth factor $= \dfrac{(1+i)^n - 1}{i(1+i)^n}$

where i is the rate of interest

n is the number of years.

XIII CRITERIA

13.1 Introduction

13.1.1 Criteria refer to standards laid down for judging whether a project is worth taking up or not. If different types of criteria are adopted, one type may result in the selection of one set of projects while another may result in the choice of a different set of projects. Which set of criteria should be chosen would obviously depend upon the objectives the decision making authorities set before themselves.

The need for criteria arises whenever choices between alternatives are to be made in a systematic and scientific manner. Such choices become inescapable in the process of resource allocation on account of the general inadequacy of funds. In the absence of objective criteria, selection is often left to be determined according to whims and preferences of decision makers and may not result in the choice of best projects. Consequently, it may arouse suspicion, discontent and resentment among sections of people. These considerations assume importance when large sums running into several hundred crores are to be spent as in the case of flood control programmes. Hence the need for objective, well-defined, and generally acceptable criteria, which can be expressed preferably in quantitative terms.

13.2 Evolution and the present status

13.2.1 *Past history*

The question of laying down suitable criteria in the case of flood control projects was raised first at the time of selecting projects for inclusion in the Second Five Year Plan. The matter came up for discussion at the fourth meeting of the Central Flood Control Board on 6th October, 1955. Since direct financial receipts from flood protection works were practically nil, the financial criterion as then applied in the case of irrigation projects could not be used for justifying any of these schemes. The Board felt that apart from technical soundness, some basic criteria must be satisfied before a project was approved for inclusion in the Second Plan. This led to the adoption of benefit-cost ratio as the major deciding criterion. It was laid down that the schemes "should generally show a favourable benefit-cost ratio. In special cases, adequate justification other than economic based on the basic needs of the specific area would have to be made out". The Board also felt that adequacy of personnel should be taken into account before sanctioning a project. In deciding priorities, preference should be given to those schemes where land required for flood protection works was offered free by beneficiaries as also those where it would be possible to realise from beneficiaries a betterment levy or cess in respect of land and property protected. The Board further directed that necessary guidelines and proformae for eliciting information required for justification of projects should be prepared by the then Ministry of Irrigation and Power and circulated to the States concerned. This was done by that Ministry in a communication dated October 12, 1955. These guidelines have been maintained ever since, except for a change effected in 1973 according to which the minimum acceptable benefit-cost ratio was raised from 1.0 to 1.1.

In the case of multi-purpose projects, benefit-cost ratios are worked out separately for each purpose on the basis of apportioned costs and benefits from each use in order to ensure that every particular purpose of the project fulfils the criterion laid down for it.

13.2.2 *Practices at State level*

All schemes submitted to the Central Government are required to satisfy the criterion of the prescribed minimum benefit-cost ratio. However, smaller schemes are generally cleared at the State level and not referred to the Centre.

While most of the States follow the criterion of a favourable benefit-cost ratio, there are some minor variations in certain States. While Gujarat and Haryana consider all schemes with benefit-cost ratio greater than unity as acceptable for execution, Uttar Pradesh and Assam approve only those with a ratio of 1.1 and above, and Bihar and Orissa restrict the choice to those with 1.5 and above. Some States, for instance, Gujarat allow schemes with benefit-cost ratio less than unity, if they are important from the point of view of protecting thickly populated areas and areas of defence and strategic importance.

Some of the States have listed other criteria also. Most of these are 'physical' in nature such as 'providing maximum protection to valuable public properties, towns, Government properities and public utilities', 'providing protection to thickly populated habitations', 'providing check to formation of new channels which could otherwise result in untold devastations', 'prevention of sandcasting', 'protection of fertile lands from floods', 'providing immediate flood protection to vulnerable areas', 'protection of land already developed', and 'damage to crops'.

13.3 Benefit-cost ratio

13.3.1 *The case*

An increase in people's welfare through the process of economic development has been the most important objective that the nation has set before itself ever since Independence. Effect of a project on economic welfare can be evaluated in terms of the relative values of benefits and costs associated with it. An excess of benefits over costs implies that people would be better off by undertaking the project. On the other hand an excess of costs over benefits would indicate diminution in welfare. It means that monetary value of loss on account of flood in an area would be less than the value of resources used in constructing the project, hence compensating them by providing relief measures or rehabilitating them would be a better policy. Thus, for a project to be taken up, it must provide more benefits than its costs.

13.3.2 A practical problem associated with any criterion based on benefit-cost analysis is that such an analysis can get distorted on account of the unreliability of statistics of flood damages and other deficiencies mentioned in Chapter XII. Sometimes, there could even be a tendency to over estimate benefits and underestimate costs for getting projects cleared.

The criterion of per hectare cost of protection could be an alternative to the criterion of benefit-cost ratio. We, however, feel that this approach has several limitations. While the norm is handy for a rough reckoning or an initial check, it is no substitute for a thorough appraisal based on benefit-cost analysis. It also ignores the fact that estimation of cost is not perfect. Secondly, a uniform per hectare cost cannot be made applicable to the whole country or even a whole State. Thirdly, it does not take into account the fact that benefits from a hectare of protected land may differ markedly from place to place depending upon the degree of urbanisation, nature of property, cropping intensity etc. in the protected area so that areas having higher benefits may tend to be discriminated against in the selection of schemes. We, therefore, consider that, other things remaining the same, the benefit-cost criterion provides the most useful way of judging the economic worth of projects.

13.3.3 It is almost axiomatic that only technically sound projects should be considered for selection. Therefore, it is not considered necessary to separately mention technical soundness as a criterion because it is subsumed under economic viability.

13.3.4 *Forms of benefit-cost criterion*

The benefit-cost criteria is expressed in several ways. One is as excess of benefits over costs, (B—C) called net benefits. Being an absolute measure, it gives direct information on the net contribution of a project to national income. However, it has a disadvantage in that it cannot be used for ranking different projects to be financed out of a given budget, unless they are more or less of equal scale which may not be the case generally. Another way of showing the relation between benefits and costs is to compute their ratio, that is the benefit-cost ratio. Being an indicator of the relative magnitude of benefits and costs it does not provide information on the absolute size of net benefits from different projects. For example, it is quite possible that a larger project with a low benefit-cost ratio may provide greater net benefits than a smaller project with higher benefit-cost ratio. However, the objective of the Government, as distinct from that of a private individual, is not to maximise net benefit from any particular project, but to maximise net benefit from a set of projects which can be financed out of a limited budget. Benefit-cost ratio, being an index of relative merit, can be used for determining priorities between projects and thereby help policy makers in selecting an optimum mix of projects. A third way of expressing the relation between benefit and cost has been through the internal rate of return which is the rate at which benefits are equal to costs or benefit-cost ratio is equal to unity. According to this yardstick, a project is worth taking up if the internal rate of return is more than the prevailing rate of interest. It has the advantage that it obviates the necessity of having a prior knowledge of the value of the interest rate which is rather difficult to estimate. This advantage is, however, illusory because unless some definite interest rate is kept in the background, it will not be possible to judge the worth of projects on the basis of this criterion. It may be mentioned that the calculation of the internal rate of return is more complex and time consuming. Moreover, under certain exceptional situations (when there are large negative cash flows late in the life of a project) there may be more than one internal rate of return. We are, therefore, not in favour of this form of benefit-cost criterion. We feel that benefit-cost ratio criterion is more appropriate for our limited purpose. Accordingly we recommend that the present criterion of benefit-cost ratio be maintained, and all projects showing benefit-cost ratio exceeding unity should be deemed as qualifying for selection.

13.3.5. *Benefit-cost ratio for improvement works*

The criterion of benefit-cost ratio would need a slight modification when applied to proposals for additional works such as raising and strengthening of embankment. The additional works are intended to increase benefits from past measures. However, it is quite possible that even after this, the total benefit from the work may continue to be less than total costs. This by itself should not, however, provide a ground for rejecting the additional work. The relevant comparison here should not be between total benefits and total costs but between incremental benefits and incremental costs. Past expenditure of sunk costs should have no influence on deciding among future alternatives except as they affect future cash-flows. Additional works would be economically justified if the ratio between incremental benefits and incremental costs is more than one. Undertaking such a work would reduce or even offset the loss from an existing losing project, in some cases it may even increase net benefits. In either case, there is gain to the society by undertaking additional works. We, therefore, recommend that in the case of additions to existing works, benefit-cost ratio criterion should be interpreted as the incremental benefit-cost ratio.

13.4 The criterion of cost effectiveness

As already mentioned in para 13.3, some of the State Governments follow physical criteria expressed in terms of specific types of property. We find that the costs and benefits of protecting most of the specific forms of property mentioned there, such as 'valuable properties', 'Government properties', 'public utilities', 'agricultural land', 'fertile land', 'crops', 'land already developed' etc. can be estimated without much difficulty and hence they are amenable to the application of benefit-cost ratio. However, in some other cases mentioned there, such as 'providing check to formation of new channel, which could otherwise result in untold devastations', 'providing protection to thickly populated habitations', etc., it may be very difficult or impossible to quantify benefits in monetary terms. Other examples could be flood control projects for protecting defence installations and places of historical importance. Places of scenic beauty and wild life sanctuaries also come under this category, if considered important. While some methods of quantifying benefits from some of the above mentioned purposes have been tried on an experimental basis in advanced countries particularly the U.S.A., no satisfactory method has emerged so far which can be used in general.

With respect to cases of the types mentioned above it would not be advisable to follow the benefit-cost criterion. Instead, judgment on the need and importance of such works has to be based primarily on subjective considerations of decision makers. However, while evaluating alternative projects for achieving a particular objective, the technique of cost effectiveness may be applied. These are two main ways of doing this analysis, known as 'fixed effectiveness approach' and 'fixed cost approach'. In the first case, a number of alternative ways of achieving a particular objective are visualised and their cost computed. While doing so, all relevant alternatives are considered. For example, in the case of defence installations, the alternative of shifting them to a safer place is also considered along with others. The alternative with the least cost is finally selected. The other way is to determine the outlay for a given purpose on the basis of budget provisions and then examine how far the various alternatives can be helpful in achieving the objective within the given resources.

Thus we recommend that the benefit cost criterion may be dispensed with only in limited and special cases where benefits cannot be quantified in monetary terms. Instead, the criterion of cost effectiveness may be followed. And among the various feasible methods, one alternative that should be considered is that of relocating settlements or installations.

Sometimes, prevention of loss of life which may take place due to floods is also used to justify projects which cannot be justified on the basis of benefit cost criterion. However, a flood which is severe enough to result in loss of life is likely to be associated with damages to crops and property. Hence schemes which tend to protect property and show a favourable benefit-cost ratio on that account are also expected to result in saving of human lives.

13.5 Degree of protection

13.5.1 A favourable benefit-cost ratio has been recommended as a basic criterion for taking up projects. However, the benefit-cost ratio of a project depends upon its scale. An embankment project in a particular locality corresponding to 25 years' flood frequency may have an unfavourable benefit-cost ratio, and hence may not be taken up. However, it is possible that if the scale of the same project is increased to correspond to a 50 years' flood frequency, it may give a favourable benefit-cost ratio and hence may be taken up for execution. Similarly, sometimes a lowering of the scale may increase the benefit-cost ratio from less than one to more than one. It is, therefore, necessary first to decide about the scale of the project before considering whether it can be taken up for execution. In the case of flood control projects, the scale is interpreted in terms of "design" flood against which protection should be provided. This flood is usually denoted by its frequency and indicates the degree of protection provided.

13.5.2 *Design criteria—where benefits are not amenable to monetary measurement*

As already indicated, there are certain projects the benefits from which cannot be quantified in monetary terms *e.g.* protection to places of historical and strategic importance. The scale of the project in such cases can be determined easily by finding out the degree of protection required by the specific objective. This will obviously vary from place to place and may be decided in the light of local conditions. The following discussion, therefore, is not concerned with these special cases but with the more general case where benefits are amenable to quantification in terms of money.

13.5.3 *Embankments*

The States have expressed differing views on the degree of protection to be adopted in case of embankments, by and large, they have suggested that the highest observed flood should be adopted as the "design" flood. Most of them distinguish the degree of protection to be provided for urban and rural areas, but some, like Andhra Pradesh, make no such distinction.

According to the Central Water Commission "the degree of protection to be provided in terms of frequency of floods is essentially dependent on the economics of the problem. It is, therefore, necessary to work out the alternative costs of works catering for different flood frequencies and the savings in flood damage for each in order to determine the proposal having the optimum benefit-cost ratio. However, at present such an analysis is not being done as neither the hydrological data for reasonable period to work out peak flood magnitudes for different frequencies nor damage data corresponding to different flood frequencies is available."

"The broad criteria at present being followed in the country are as below:

(1) Predominantly agricultural areas	25 Years flood frequency on small tributaries and 50 years flood frequency on major rivers.
(2) Town protection works	100 years flood frequency
(3) important industrial complexes, assets and lines of communications	100 years flood frequency

Since enough long range hydrological data is not available and since the results of frequency analysis on the basis of short term data can be misleading, the general practice followed at present is to adopt the above frequencies or the observed maximum flood in the recent past, which ever is higher." The CWC have further stated that "...where the frequency studies have been carried out on the basis of a long-term data, works for agricultural areas should be designed only on the basis of frequency specified and not on the basis of observed data even if it is higher. However, in the case of towns, each case will have to be considered on its merits depending upon the damage potential, further growth of the town after the original construction of works etc."

According to the Ganga Flood Control Commission, "Subject to availability of observed hydrological data, the design High Flood Level may be fixed on the basis of flood frequency analysis. In no case, should the design High Flood Level be lower than the maximum on record. For small rivers carrying discharge upto 3000 cumecs, the design High Flood Level shall correspond to 25 years return period. For the rivers carrying peak flood above 3000 cumecs, the design High Flood Level shall correspond to 50 years return period. However, if the embankments are to protect big towns, industrial areas or other places of strategic importance, the design High Flood Level shall generally correspond to 100 years return period."

Thus the general practice in our country is to design projects to provide flood protection against maximum observed flood. Quite often existing structures are raised in case a higher than the designed flood comes. The maximum observed floods may include those which could be even exceptional. A design flood based on the maximum recorded flood may therefore tend to raise the scale of a project to a very high level resulting an undue concentration of resources in some areas to the neglect of other areas. Or work in different areas may be started to satisfy local pressures, but their completion may be delayed due to budget constraint. In either case, society is deprived of the maximum benefits from its limited resources. However, there is also a possibility that sometimes the desire to provide protection against the maximum recorded flood may not result in any viable project on account of its heavy cost. For example, suppose that the maximum record flood is of 100 years' frequency. If a scheme protecting against this frequency is prepared, it is found that the costs go up so high that the benefit-cost ratio is less than one. Hence this scheme may not be taken up and the area deprived of any protection against flood. However, it may be possible to prepare a viable scheme by reducing the frequency to a lower level, say 50 years'. In view of the considerations mentioned above, we are not in favour of this criterion except in special cases.

The criterion in terms of different flood frequencies for different types of areas is somewhat better than that in terms of the maximum observed flood because it tries to relate the scale to the economic condition of different areas. However, even this criterion does not take the local conditions and the damage potential fully into account because the frequencies are kept uniform for all types of agricultural (or industrial) areas, regardless of the level of productivity of the area and the nature of property protected. The scale of the project would remain the same irrespective of other developments which may take place subsequently for example, activities like intensification of agriculture, introduction of high yielding varieties of crop etc. which tend to raise agricultural production and damage potential in the years after the construction of the project. It is also not clear as to what is the basis behind these frequency figures. Moreover, this criterion like the earlier criterion based on maximum recorded flood may result in denying protection to certain areas altogether. Suppose the application of a 25 years' flood frequency results in a project with a benefit-cost ratio less than one. In that case, the project will not be taken up. However, it is quite possible that if we select a higher or a lower frequency, the benefit-cost ratio may become favourable. Thus certain areas may be denied protection because they were judged by wrong standards.

In view of the wide variations in the physical, agricultural and overall economic conditions of different areas and also in view of non-uniformity in river's behaviour, the best course should be to relate the scale of a project to local conditions and damage potential. A richer and more developed area having higher damage potential can afford to have a higher scale of protection. In other words, the scale of a project should be determined by conducting a benefit-cost exercise. After examining a few flood frequencies, the frequency which provides the maximum benefit-cost ratio may be selected.

Example

Flood frequencies	Benefit-cost ratio associated with each frequency
10 years . .	0.8
20 Years . .	1.5
30 Years . .	2.7
40 Years . .	1.8
50 Years . .	0.7

In the example given above, the scale corresponding 30 years' frequency may be selected. This criterion helps the authorities to deploy their limited resources as efficiently as possible. The attempt to optimise the net benefit from the limited flood control budget is first made by adjusting the scale for finding out the optimum scale and then giving preference to an individual project depending on its benefit-cost ratio. On account of additional development that might have taken place subsequently, thereby increasing the damage potential, it may become justified to raise an embankment. The above criterion is fairly general and would apply as much in case of embankments as in drainage and other alternatives wherever benefits are amenable to quantification in monetary terms. The practice of taking maximum net benefit into account for determining the scale of any flood control project has already been adopted in the USA.

The use of the benefit-cost criterion would require (i) damage data with respect to different flood frequencies, (ii) data on damages due to probable failure of embankments, and (iii) expertise to carry out alternative benefit-cost and trade off exercises. These are not available at present. Hence, for the time being we recommend, as a general guide, adoption of the following criteria based on flood frequencies:

(i) for predominantly agricultural areas: 25-year flood frequency, (in special cases, where the damage potential justifies, a higher design flood/maximum observed flood, may be adopted),

(ii) for town protection works, important industrial complexes etc: 100-year flood frequency, (for large cities like Delhi, the maximum observed flood, or even the maximum probable flood should be considered for adoption).

Meanwhile, studies should be undertaken to review the basis of these flood frequencies and attempts made to collect the data and appoint the necessary personnel, so as to enable the application of benefit-cost criterion in due course.

13.5.4 *Flood storage in reservoirs*

The normal degree of protection for different types of developments has been suggested in the last paragraph. As far as flood moderation is concerned, the storage to be provided in a reservoir can be determined for the specific degree of protection after taking into account the safe capacity of the channel downstream. This storage should, however, satisfy the minimum benefit-cost ratio.

The flood storage can also be fixed on the basis of alternative studies of floods of different frequencies, the storage required for moderating the different floods to the safe channel capacity and the corresponding benefits. Thereafter, the storage that gives the optimum benefit-cost ratio may be selected for adoption.

It may be pointed out that the spillway design flood which is meant for the safety of the structure should be determined according to the criteria applicable to such structures.

13.5.5 *Drainage projects*

Given the necessary data, the scale of a drainage project as in other cases should be determined by the benefit-cost considerations. The criteria would, therefore, vary from area to area depending upon cropping pattern, the period of tolerance of standing crops to submergence, the depth and duration of stagnant water etc. Accordingly, varying standards have been specified by States to take care of local situations. These may be reviewed from time to time in the light of changes in agricultural situation and additional experience gained in this respect. Eventually depending upon the availability of needed data and personnel at micro-levels, the introduction of benefit-cost criterion may be considered.

13.6 Inter-se priorities

13.6.1 Resources for financing flood control projects being limited, all schems which fulfil the criteria mentioned earlier cannot be taken up for execution. This raises the question of priorities among schemes which satisfy the basic criterion of benefit-cost ratio. The importance of this question seems to have been realised during early fifties when a number of steps were taken in the field of flood control. The first responsibility given to the Central Flood Control Board which was created in September, 1954, was to draw up a comprehensive plan for flood control and fix priorities. This responsibility also figures in the functions of the River Commissions, State Flood Control Boards and their Technical Committees.

13.6.2 *Past recommendations and present status*

The High Level Committee on Floods (1957) had stated that "Unless other considerations dictate otherwise, the more favourable the cost-benefit ratio, the higher the priority that a work would deserve." In addition, the Committee gave the following order of priorities: (i) emergent schemes, (ii) continuing schemes, (iii) schemes for the protection of important urban and industrial communities, (iv) schemes which help in augmenting food production in the country, and (v) schemes which combine other beneficial utilisation of water.

Most of the State Governments in their reply to our specific questions have indicated that schemes with higher benefit-cost ratio should be given priority. In addition, like the High Level Committee, they have also made reference to priorities in physical terms. They have suggested that schemes, like those for protection of cities, towns and village abadies as also areas threatened with immediate danger to life and property should receive priority. Another category of schemes recommended for priority treatment are those intended to protect areas where floods and damages due to floods are severe. Equal importance is suggested for schemes for repairs and strengthening of embankments. As we have said earlier, several of these physical indicators form part of overall criteria of benefit-cost ratio and need not be stated separately.

It would appear that in actual practice, and by and large, no order of priorities is followed. Schemes are sometimes taken up in an *ad-hoc* manner on political and other extraneous considerations. Quite often, schemes taken up are in response to emergent situations and in such cases the question of following any set of criteria for fixing *inter-se* priorities does not arise. These lean heavily on the subjective judgement of executive agencies and decision makers as there cannot be any objective criteria or determining urgency rating. According to the High Level Committee, emergent schemes should cover all schemes of strategic importance. Schemes meant for protection of religious, historical and other monuments or places may also get included under this category. Such schemes are not likely to be many. However, in practice, the meaning of emergent schemes has been extended to cover threat to private agricultural lands and dwellings on account of river erosion. Moreover, as the Central Water Commission have pointed out, the question of following any priority does not arise because no State has finalised any master plan so far. Priorities become relevant only when there is a shelf of projects complete with details of investigations so that a rational choice may be made among them. Moreover, experience indicates that priorities in execution of schemes in States sometimes change with the change of political leadership and atmosphere. Consequently less emphasis is given to earlier schemes and new schemes in new areas are taken up on priority basis. This complete disregard of a given set of priorities has resulted in delay in completion of projects, a very thin spread of limited resources over a number of projects and taking up of projects beyond the financing capacity of State Governments. This is not a healthy state of affairs. We, therefore, recommend that selection of projects for execution be made on the basis of a well conceived system of priorities.

13.6.3 *Selection of new schemes*

The limited resources available for flood control should be utilised in such a way as to produce maximum benefits. The return to limited budget can be maximised by selecting projects with respect to their benefit-cost ratios. A project with higher benefit-cost ratio should have a higher priority and *vice-versa*. In addition to the basic criterion of benefit-cost ratio, there may be a few other considerations before policy makers. These may be economic as well as non-economic. Important considerations which we consider relevant from this point of view, in the context of declared aims and objectives of the policies of the Government are mentioned below.

Creation of employment potential has been declared an important goal of national policy and should therefore exercise some influence on project selection. However, it is not possible to lay down any precise criterion in this respect *e.g.* in terms of number of people employed per project or per unit of capital. What is possible is that, other things being equal, an alternative having a higher employment potential should have priority over those having lower potential. According to instructions issued by the Planning Commission, information regarding numbers of various types of persons to be employed on projects is to be included in the Report. It is suggested that it may be supplemented by details of the wages to be paid and the ratio between number of persons to be employed and capital cost (labour capital ratio) worked out. The higher this ratio the more desirable the project from this angle.

Of late, environmental and ecological aspects of projects have come to receive an increasing emphasis. Flood control, drainage, and other water resources projects produce effects on environment and ecology which may be both favourable as well as unfavourable depending upon situations. Various examples can be given. Embankments by preventing silt deposition on flood plains affect land building activities. Flood control reservoirs affect the regime of the river below. But they also create recreational facilities and by providing water on a perennial basis may attract animals and birds. Hence while designing any flood control project, its effect on environment and ecology should also be taken into account so as to minimise the adverse effects and increase the scope for favourable effects. Environmental factors can, however, be measured by a large number of physical and subjective parameters, and, therefore it becomes very difficult to evaluate them in any quantitative manner. Hence all that is possible is that the environmental and ecological aspects of different alternative projects be described in a qualitative manner so as to enable the decision makers to arrive at some judgement.

Protection of life and mitigation of human suffering could be other important considerations. People affected by flood suffer several inconveniences other than damage to property. These inconveniences cannot be quantified. However, one can say that other things being equal, the greater the number of people being affected in a given area, the more important the need for protection. For this purpose information on density of population in the flood affected area as well as per capita expenditure on flood control in the project area may also be given so as to enable policy makers to arrive at a judgement.

13.6.4. It is obvious from the foregoing discussion that besides benefit-cost ratio, there are three other considerations which should claim our attention for determining *inter-se* priorities of flood control projects. We, therefore, recommend that the *inter-se* priorities among new flood control projects, generally from amongst those included in the master plan should be fixed in the light of the following factors:

(i) benefit-cost ratio;

(ii) employment potential;

(iii) effects on environment and ecology; and

(iv) density of population in the flood affected area as well as per capita expenditure on flood control in the project area.

Some of these criteria may conflict with each other in the sense that a project thought better from the point of view of one consideration may be worse from the point of view of another consideration. In such cases, a decision can be taken only on the basis of an overall picture.

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XIV FUTURE APPROACH

4.1. Introduction

The starting point for evolving our future pproach to the problem of floods would be the indsight evaluation of the benefits and effectiveness of the flood protection measures since he initiation of the National Flood Control Programme in 1954. Our review of the past pproach and achievements in Chapter VI, has hown that the major thrust in the past has een on physical methods for flood control, nainly in the channel phase, such as, by contruction of embankments, drainage improvenent works, and anti-erosion works. Flood forecasting, a non-physical method, introduced in ecent years, has proved helpful in reducing lamage to life and movable property. We have een in Chapter XIII, how development works and encroachments have, sometimes, accentuated he problem of floods in unprotected areas, as well as in areas provided with some degree of protection by physical measures. The analysis of flood damage data in Chapter IV, has shown hat in spite of an investment of the order of Rs. 650 crores upto March, 1978, since the initiation of the flood control programme in 1954, osses due to floods show an increasing trend even at constant prices. Emergency measures for relief have been increasingly resorted to, after flood disaster have wreaked their havoc.

14.2. Policy objectives

14.2.1. Flood control should not be considered as an end in itself, rather it is the means to an end. Flood control has to be viewed within the broad context of the economic and social development in the country. India is a relatively poor country, with a large and expanding population, about 70 per cent of which is dependent on agriculture. It, therefore, seems to us that the comprehensive approach to the problem of floods must form part of the overall comprehensive approach for obtaining the best possible utilisation of our land and water resources for optimum production of food, fibre, fodder and fuel, to meet the needs of the growing population. Water being a vital input for human, animal and plant life, and also for industry and water transportation, the importance of total harnessing of water resources cannot be everemphasised. Management of floods should be considered in the context of the overall plan for management of the water resources of a river basin. Losses to life and property by either shortages or surpluses of water, i.e., by droughts or floods, must be minimised. The approach to the flood problem has also to take into account the state of our economy, our social conditions, and the availability of resources. The approach, therefore, cannot be static, but should remain dynamic and flexible, so as to accommodate future improvements in policy, if called for, in subsequent reviews.

14.2.2. While the above would be the objective at the national level, the objective at the local level can sometimes be different. Within a State or a smaller local area, the objective would be the economic and social well-being of its citizens. However, local goals sometimes conflict with overall national goals and have to be reconciled. For example, people living in the flood plain would like to be provided with complete security against floods by physical flood control measures, irrespective of the costs and/or adverse effects which may be caused elsewhere in the basin. However, if the costs are more than the benefits, this would result in a net loss to the economy, which would harm the nation as a whole, as well as all the constituent parts.

14.3. The problem and its causes

14.3.1. The incidence and extent of the flood problem have been dealt with in Chapter III. Out of about 40 million ha. of area liable to floods in the country, reasonable protection has been provided to only about 10 million ha. up to March, 1978. The analysis shows that the average annual damage during the period 1953—78 amounts to Rs. 282 crores. This has shown a tendency to increase rapidly in the last few years.

14.3.2. The direct cause of flood flows in India is the fact that rainfall is largely concentrated in the rainy season, and quite often in a few spells of heavy rain, because of which the resulting run off cannot be contained within the drainage/river channels and overflows on to the flood plains.

14.3.3. The situation is further complicated by the heavy silt load in the rivers, especially those debouching abruptly from the high, steep and friable Himalayan ranges to the flat alluvial plains. Faulty land use and deforestation are contributing factors aggravating the problem.

14.3.4. On the other hand, flood plains have always provided attractive locations for various human activities, with the result that settlement in flood plains is continuously increasing, thus adding to the flood damage potential.

14.4. Identificatoin of alternative methods

14.4.1. In the past, the emphasis has been on physical methods of protection from floods. We would, however, suggest that all types of measures, physical or otherwise, that could be helpful in dealing with the problem, should be considered for flood management. These may comprise physical, biological, economic, social and administrative such as, soil conservation and afforestation, reservoirs, embankments, drainage channels, dredging, flood plain regulations, flood forecasting and warning, emergency measures, flood insurance, etc. In the absence of any viable measure, one may have to live with floods. The suitability of the measures would vary from case to case depending upon location, nature and magnitude of the flood problem, availability of funds etc. The task of planning lies in selecting the optimum combination of the measures available for tackling the problem in a given situation.

The usual approach in the past has been adoption of a feasible flood control measure, which based on the experience and intuition of the planner, seemed most apt. This approach does not exhaust all feasible alternatives and may not result in the best choice. It would be preferable to list all the possible flood control measures, and to design their various combinations as alternatives, in a more or less exhaustive approach. By using various constraints and criteria, the number of alternatives can be reduced to a small set which may be subjected to detailed economic and social analysis.

14.4.2. Alternative methods of dealing with the problem of floods are listed in Chapter V. For choosing an optimal package of measures, it is necessary that officers concerned with floods, at all levels of administration, should become familiar with the full set of possible adjustments to floods, regardless of whether or not these have been adopted, in their geographical or functional area of responsibility before, and examine the relative merits of each, in technical, social and economic terms.

14.4.3. Annexure 14.1 shows the appropriate applications, special features, and implications for policy-making, for various types of potential adjustments to floods *i.e.*, flood protection, watershed management, weather modification, flood plain management, flood proofing and emergency measures.

14.5. Need for water conservation

As already stated, the direct cause of flood flows in India, is the fact that rainfall is largely concentrated in the rainy season, and often, in a few spells of heavy rain. This considered along with the objective of obtaining the best possible utilisation of land and water resources, leads to the obvious conclusion, that there is a need for storage in various forms, which would even out the flow, and also conserve water for use during dry periods. Measures such as afforestation, and watershed management help in conserving water through increased percolation, and in retarding run off to some extent in addition to their primary role of enhancing land productivity and reducing soil erosion. Measures, primarily for water conservation, like small, medium and large reservoirs, natural detention basins, ground water storage etc. help in moderating run off depending on their capacity, and should be the first to be considered while planning measures for flood management in any basin or sub-basin.

14.6. Afforestation and soil conservation

Afforestation and soil conservation measures have been elaborated in Chapter XI. These measures are more effective in moderating relatively small and medium floods than in damage-producing high floods resulting from prolonged spells of heavy rain. While their role in moderating large floods may not be significant, their contribution to the preservation of the soil mantle, and maintenance and enhancement of the ecology and land productivity on a long-term basis, is important. The reduction of sediment load through these measures is also important, especially in aggrading rivers. Hence they are recommended as a useful complement to other measures, and should be taken up in the watersheds of rivers with heavy silt charge.

14.7. Reservoirs

Reservoirs in general, even without specific flood storage space, have a beneficial effect on the flood problems of a basin. The effectiveness of reservoirs in moderating floods would depend upon the capacity available for absorbing flood runoff. Because of their high cost, reservoirs may well be justified for direct benefits like water supply, irrigation and hydro-electric power generation, but are likely to be uneconomical if constructed exclusively for flood moderation. It is, therefore, good practice to construct multi-purpose reservoirs with flood moderation as one of the functions, instead of reservoirs solely for flood moderation.

Compared to other physical measures, reservoirs take a longer period for their investigation and execution. Also quite often, the available sites for reservoirs are remote from the areas where flood damages occur, whereas their flood moderation impact decreases with distance. On the other hand, under favourable conditions, reservoirs are a dependable measure, which, by itself or in combination with other measures can considerably mitigate the flood problem of a river basin. Reservoirs to the extent technically and economically feasible, must be considered as an important component in any package of measures for flood management. Reservoirs would also ensure the maximum utilisation of water resources.

14.8. Natural detention basins

In the utilisation of natural depressions for flood detention, often a conflict arises between the desire to drain out and reclaim such areas for agriculture and the desire to preserve them for moderating floods. As a via-media, these could be reclaimed by drainage and peripheral embankments and used for agriculture in years of moderate and medium floods. In such cases, their natural storage, enhanced if possible by peripheral embankments, should be brought into use for flood moderation during abnormal floods. This will obviously imply loss of agricultural production during years of high floods which occur rarely but will enable the land to be used for agricultural production in most of the years. Use of such depressions for moderating high floods implies that restrictions must be imposed on high risk investments in such areas.

Permanent water bodies like beels and lakes could be developed for pisciculture and aquaculture and also used for flood moderation where feasible.

We recommend the use of natural detention basins for flood moderation. where natural conditions permit.

14.9. Underground water storage

A large proportion of the rainfall infiltrates into the ground and maintains soil moisture and ground water. To the extent that the infiltration is increased, the direct surface runoff is decreased. A substantial part of the rain water, which infiltrates into the soil, is used up by evaporation or evapo-transpiration, and does not appear as surface runoff. Part of the water which percolates into the ground water zone reappears as surface water in springs and streams, mostly after the peak of the flood runoff has passed. Measures for increasing ground water recharge are, therefore, conducive to reduction of flood runoff. This may be in the form of land management for water conservation, water spreading, water harvesting structures, recharging wells etc. The additional water, thus conserved in the ground water reservoir, can be drawn upon for utilisation in dry periods. Although artificial methods for ground water recharge do not have wide application as yet, we recommend that research and development be carried out and such measures considered, while drawing up flood management plans.

14.10. Safe disposal of surplus runoff

The intensity and duration of runoff and the resulting volume of runoff in high floods is so large that water conservation measures may not be adequate. After heavy storms large volumes of surplus runoff will have to find their way to the sea through the drainage network of streams, rivers and tributaries. The capacity of the natural drainage system is seldom enough to safely carry large flood flows. Measures like embankments, channel improvements, emergency floodways, river diversions and interbasin transfers, may have to be adopted.

14.11. Embankments

14.11.1. *Introduction*

Embankments or flood walls have been and will remain one of the most important physical methods for flood control. They have several advantages, in that they give direct benefits by keeping out flood water from threatened areas by comparatively economical structures, which are easily constructed with locally available materials and labour, in comparatively short periods. There, however, are some problems or side effects associated with embankments which have been referred to in Chapter V. It is important that in planning the use of embankments as part of the flood management programme for a basin, the associated problems and side effects are kept in view, and minimised to the extent possible.

14.11.2. *Vulunerability to river attack*

With the desire to protect as much land as possible, embankments are often aligned close to the river edge. They may appear reasonably safe at the time of construction but, on account of the everchanging nature of the river course, do come under attack later. After construction of embankments. large amounts have sometimes, to be spent on protecting them from river attack, particularly in the case of embankments along aggrading and meandering rivers. It is, therefore, necessary that embankments be aligned at a reasonably safe distance from the river to minimise subsequent expenditure on protection.

14.11.3. *Rise in flood levels upstream and downstream*

In Chapter V, we have seen that embankments raise flood levels by reducing the cross-sectional area of overbank river flow. The peak of the flood hydrograph is also increased by cutting off river spills and flood storage. Both of these causes result in a rise of flood levels upstream and downstream of the reach in which embankments are constructed. This may create new problems of flood to areas upstream and downstream.

Sometimes, spurs constructed to protect a section of an embankment on one bank of a river, have an adverse effect on the opposite bank. If a series of spurs are constructed from both banks of a closely embanked river the area of flow of the river is further reduced, raising flood levels upstream.

There is also a tendency of rise of the river bed in postembanked conditions in aggrading rivers. Such a rise, coupled with higher flood levels in embanked rivers, may also accentuate problems of drainage congestion in the protected area.

14.11.4. *Problem of country drainage*

Embankments are not a feasible measure of flood protection, in cases where the country runoff draining into the river is so large as to inundate appreciably the area protected by the embankments from river spills, during periods when the river is running at high flood stages.

14.11.5. *Need for study of side effects*

Quite often, such effects are not studied by planners and designers, partly perhaps from insufficiency of data. The Commission recommends that such studies be made obligatory before embankment schemes are approved.

14.12. Channel improvement

Channel improvement has not been resorted to widely in India, mainly because of the high costs involved in excavation or dredging of channel sections below water and the continual expense of maintaining the improved channels, which tend to revert to their original condition because of silting.

They have the advantage that in the local reaches where they are executed, flood levels are generally reduced, contrary to the case of embankments, where flood levels tend to increase. On the other hand, in common with embankments, by the very act of reducing flood spills and inundation of adjoining lands, they increase the peak discharge of the flood hydrograph. The high initial and maintenance cost of channel improvement make it obligatory that this measure should be considered with due caution.

14.13. Emergency floodways and river diversions

Measures like emergency floodways and river diversions are useful for flood control, but can be resorted to only in rare cases, where topography and other conditions are favourable.

14.14. Interbasin transfers

Inter-basin transfer of water has a very limited impact on flood discharge. Due to practical limitations, the quantum of discharge in interbasin transfers is small as compared to the discharge experienced in damage-producing floods.

14.15. Bank protection and anti-erosion works

The capital and maintenance cost of anti-erosion works is extremely high. In this connection, we agree with the resolution adopted in the Fourth State Irrigation Ministers Conference, that anti-erosion works should normally be taken up only for protection of towns, industrial areas, groups of thickly populated village *abadis*, railway lines and roads, where relocation is not possible on techno-economic grounds. These works should not be taken up for agricultural areas where the assets protected may not justify the cost. In such cases rehabilitation of the affected population and assets elsewhere should be considered.

14.16. Drainage improvement

14.16.1. Surface water drainage congestion, due to inadequacy of natural or artificial drainage channels, causes damage to agricultural crops. Therefore, drainage improvement by construction of new channels or improvement in the discharging capacity of the natural drainage system, are an inportant part of the flood control programme and should rightly continue as such.

14.16.2. As increased drainage reduces the extent and duration for which surface water remains on the land, ground water recharge is naturally reduced. Thus, increased drainage can lead to waste of valuable water. Occasionally this can give rise to complaints of lowering of the water table, especially in areas where rainfall is deficient. To minimise this, it is recommended that drainage water be utilised for irrigation, as far as possible, by leading it into an irrigation system lower down, or where economically justified, by storage and pumping.

14.16.3. Sometimes, drainage improvement in areas upstream can lead to problems of drainage congestion and flooding downstream. To guard against this, measures for drainage improvement should be planned and executed in a co-ordinated manner, starting from the downstream end. This would require increased cooperation in the case of drainage systems covering more than one State.

14.16.4. Drainage congestion sometimes occurs behind embankments due to high stages of the river. In such cases, drainage channels may have to be constructed parallel to the river to discharge at points downstream where the river levels permit. In urban areas, pumping would have to be resorted to.

14.16.5. Heavy irrigation occasionally leads to rise in the subsoil water table and waterlogging. According to the accepted policy, drainage of such areas should form an integral part of the irrigation programme. In fact, measures for irrigation and drainage should be fully integrated, in order to derive the maximum benefit from irrigated agriculture.

14.17. Physical measures not enough

In the preceding paragraphs, we have dealt with physical measures attempting to modify the flood. However, these by themselves are not enough. It is well known that it is not practicable to protect all areas against floods for all time to come. Physical measures of flood management are generally designed to provide a "reasonable" degree of protection against medium and moderately high floods, consistent with technical and economic feasibility. They do not provide protection against extremely high floods which have a very low frequency of occurrence. If and when the protection measures fail, on account of such a rare flood, the consequent damage is far more than if no measures had been implemented. This is because these measures may provide protection for several years thereby engendering a sense of security, because of which there is often accelerated development in the flood plain. Again, there may be areas where physical measures for flood management are not possible because of financial and other constraints. Therefore, in addition to measures attempting to modify the flood, measures attempting to modify the susceptibility of life and property to flood damage, are also called for.

14.18. Modifying susceptibility to flood damage

As already mentioned in Chapter V, the second approach for flood management is to modify the susceptibility of property and activities in the flood plains to the ravages of floods. This approach is usually carried out by flood plain management, development and redevelopment policies, structural changes for flood proofing, flood forecasting and flood warning, disaster preparedness and response plans etc. This strategy is expressed as actions to avoid dangerous, uneconomic, undesirable or unwise use of flood plains. Experience in other countries has shown that not only are such adjustments helpful, but they also cost less than conventional flood protection measures. Also, this approach tends to reduce the burden of costs on the public at large and to place it on those who reap the advantages of flood plain location. The result is that it also promotes increased awareness of the need for efficient flood adjustments.

It may, however, be mentioned that the above measures for modifying the susceptibility of property and activities in the flood plain to flood damage, may not reduce damage to agricultural crops, which at present constitutes about 60 per cent of the average annual flood damage in the country. For reducing damage to agricultural crops, for those areas in the flood plains, which cannot be technically or economically protected by physical measures, the Commission recommends that efforts be made to evolve suitable cropping patterns and crop varieties, which are more tolerant to inundation by flood water, and less susceptible to damage. Such adjustments of cropping patterns are mentioned in Chapter XI. In addition, more use of relatively flood free periods has also been recommended for growing crops.

We must also mention that the proportion of damage to property and public utilities, has already risen from about 24 per cent to about 40 per cent of the average annual flood damage since 1954. The trend is towards increase of damage to property and public utilities, in spite of about Rs. 650 crores having been spent on flood control since the inception of the programme. This is obviously due to increased developmental activity in the flood plains, as also in those areas which, though provided with reasonable protection, are still liable to damage by floods higher than the design flood, or by failure of the structures. The trend towards increase of such damage will not be checked, unless steps are taken to regulate activity in the flood plains, and adopt other measures for modifying susceptibility to flood damage.

14.19. Disaster preparedness

Disaster preparedness can minimise loss of life and property by planning, in advance, measures to meet the disaster. Such measures are flood forecasting and flood warning, flood fighting, evacuation, community shelters for people, and raised shelter platforms for their domestic animals. All these measures involve human adjustments, designed to minimise flood losses, while at the same time trying to make the best use of the flood plain during flood free periods.

14.20. Importance of non-physical measures

The Commission recommends the approach of adoption of measures for modifying the susceptibility to flood damage to a much more increasing degree than in the past.

14.21. Other physical adjustment measures

Measures like raising of villages, ring-bunds around habitations, etc. have also been tried in parts of this country and have proved useful in certain locations.

14.22. Modification of the loss burden

In spite of physical and non-physical measures, some flood losses will continue to occur causing misery and hardship to those affected. It is but natural that measures should be taken for relieving the misery and modifying the burden of loss, so that those affected are not crippled financially, thereby becoming a burden on society. This brings us to the third approach to flood management, *viz.* to spread the loss burden over a larger segment of the community than that immediately affected, or by spreading it more evenly over time. Disaster relief and tax remissions spread the flood loss over the community as a whole, and taccavi and other loans and flood insurance spread it over a longer period of time. Measures like disaster relief and remission of taxes and taccavi loans etc. are already in use in the country and will have to be continued.

14.23. Flood insurance

Flood insurance has been adopted only to some extent in some parts of the world. It has not been tried in India. The difficulties have been described in Chapter V.

Insurance can be successful where it covers a class of people who are subject to the risk of losses more or less equally, but the incidence of losses is random and on any single occasion affects only a small proportion of the people insured. In case of floods, the risk of flood losses even in an area liable to floods is not equal. Those owning land or property at a lower elevation in a flood plain are subject to higher risk, both in magnitude as well as in frequency. Therefore, those living at higher levels, would not be equally willing to buy insurance cover. It is difficult to calculate the differing risks accurately and adjust the insurance premium accordingly. However, there certainly is need for insurance programmes as mentioned in Chapter V. In spite of the difficulties, there is need to conduct research, and if possible, take up pilot projects for flood insurance.

14.24. Basinwise comprehensive approach

In the preceding paragraphs, we have attempted to identify and discuss briefly the various alternative methods of flood management. Among the problems identified, we have mentioned that local or narrow functional approaches often conflict with the interests of the basin or the region or the nation as a whole. For example, in the case of embankments, we have mentioned that construction of embankments in certain areas can lead to increase in flood levels upstream and downstream, accentuating the flood problem in adjacent areas. Construction of embankments on the river Yamuna in Haryana and Uttar Pradesh, and in the rural areas of Delhi, have tended to increase the flood threat to the city of Delhi. Similarly, drainage of depressions naturally liable to floods in Haryana and Rajasthan, in the Ujjina-Pahari-Kama-Goverdhan drainage system, have led to increased flood distress downstream. As a result of such situations the downstream riparian States have often resorted to retaliatory action. For obviating such difficulties, it is necessary that flood control problems are dealt with on a basinwise basis. Floods do not pay any regard to artificial district or State boundaries. For flood control planning, as for water resources planning, the basin must be treated as the unit.

14.25. Future approach

The Commission recommends that the comprehensive approach to the problem of floods, should form part of the overall comprehensive approach for obtaining the best possible utilisation of our land and water resources for optimum production, on a sustained long-term basis, preserving and enhancing the ecology and minimising loss of life and property by either shortages or surplus of water, *i.e.* by droughts or floods. To achieve this, the following points are considered important:—

(i) The planning should be basin/sub-basinwise keeping in view their individual techno-socio-economic conditions and reconciling the local interest with the overall regional or national interest. The possibility of interbasin transfers of water should, however, be kept in view, with the help of storage reservoirs, as necessary and feasible. It is recommended that the Centre should take control over regulation and development of inter-State rivers by assuming the necessary powers under Entry 56 of List I (Union List) of the Constitution.

(ii) Master plans for flood management should be drawn up after a thorough study and evaluation of all the alternative methods available, both physical and non-physical.

(iii) In the comprehensive approach, measures for conservation and utilisation of water resources for multiple benefits should receive due emphasis. However, in spite of water conservation measures, flood runoff will still remain to be dealt with by other methods of flood management.

(iv) Non-physical measures such as regulation of development in the flood plans, flood forecasting and warning, evacuation of the population to floodproof shelters, and other rescue, relief and rehabilitation measures forming part of detailed disaster preparedness plans, are very important. The willingness of the local people for and progress made by them in the implementation of such measures should be taken into consideration before execution of physical measures for flood control.

(v) The execution of the comprehensive plan for any basin or sub-basin will have to be taken up in a phased manner, consistent with the State of our economy. Flood control planning, however, must be continuous and dynamic to keep pace with socio-economic changes.

(vi) It is hardly probable that a single measure by itself would be the most effective in mitigating the flood problem at any one location. It is more than probable, that a combination of measures would be most effective and economical. It is, for example found that, of all the structural measures, a combination of storages with embankments is a satisfactory strategy to be adopted. This, for example, has been proposed for the Brahmani and the Baitarni rivers in Orissa. Effective land use regulations in the areas protected by the embankments should be an added measure. Similarly, where storages are either not possible or are not likely to fructify in the near future, a combination of embankments/flood walls and diversions/floodways could be considered, as has been done in the Jhelum river near Srinagar. Thus various applicable combinations of strategies should be considered while dealing with the problem in various basins/sub-basins.

14.26. Out of about 40 million ha of area liable to floods in the country, reasonable protection has so far been provided to only about 10 million ha. The flood problem of the basins/States vary with local conditions.

We have briefly examined the flood problem, considered the proposals made by the States, and, suggested basin-wise and State-wise measures in the pages that follow.

We would like to reiterate that non-physical measures of flood management like modifying the susceptibility to damage, spreading the loss burden, land management and land use, flood forecasting and warning and the like are recommended in all flood-prone basins; as such, they are not repeated State-wise.

THE BRAHMAPUTRA BASIN

14.27. The Brahmaputra Region

The region comprises the basins of the Brahmaputra and Barak rivers and their tributaries. The former includes rivers like the Teesta, the Torsa and the Jaldhaka, which flow through Sikkim and northern parts of West Bengal. The region covers the State of Assam, northern portion of West Bengal and North-eastern States of Manipur, Tripura and Nagaland and the Union Territories of Arunachal Pradesh, Meghalaya and Mizoram. The flood problems of North Bengal are distinct from those of Central and South Bengal. The two regions are, therefore, separately dealt with, the former in the Brahmaputra and the latter in the Ganga Basins respectively.

The Brahmaputra is one of the largest rivers in the world and carries over 30 per cent of the total water resources of the country. It is subject to lateral shifts. The tributaries on the north come down steep slopes bringing heavy silt charge; their impact causes the river to shift southwards. The tributaries on the south have flatter slopes and the lateral shift of the river results in shifting of the confluences of the southern tributaries. The braided nature of the river results in shifting channels and avulsions into the tributaries etc.

As in most alluvial rivers, the land slopes away from the river edge in certain reaches. This results in difficulties of country drainage.

The terrain is hilly and covered with forests and the foothills with tea gardens. This leaves narrow valleys to sustain increasing population. As such there is encroachment in the flood plains.

The northern tributaries of the Brahmaputra are subject to erosion, evulsions and aggradation. The valleys between the streams are narrow and subject to drainage congestion.

Tributaries flowing through Sikkim and North Bengal have steep slopes and bring down large quantity of silt with high velocity, resulting in aggradation of river beds, erosion of banks and changing of river courses.

The Barak basin lies to the south of the Brahmaputra valley. The valley is narrow and receives heavy rainfall. The river has a flat slope and there are depressions on either side. Floods in the Barak back up into the tributaries. Overspills fill up the depressions called 'haors', thus leaving little dry land in the valleys.

The major problem in this region is heavy flooding of land and silt loads in rivers. These in addition to overspilling, result in aggradation, change of river course and bank erosion. Earthquakes in the past have resulted in land deformations and rise in river beds. Deforestation, cuttings in hill side for developmental works like roads, and, shifting cultivation cause further problems by way of soil erosion and quick run-off.

Storages on rivers are positive factors in flood control/protection. Storage sites have been located on the Dehang and the Subansiri tributaries of the Brahmaputra; these have possibilities of large hydro-power generation as also of flood moderation, which may lower the peak levels in the river and tributaries by about one metre. Similarly, a site for storage reservoir has been located at Tipaimukh on the Barak river. Multipurpose storages on other tributaries of these rivers also appear to be possible. High seismicity of the area, heavy sediment load in the rivers and difficult foundation conditions are the important problems which will have to be solved when planning and constructing dams in this region.

Watershed management and control of shifting cultivation would be useful towards mitigation of floods and flood damage.

14.27.1. *Assam*

The problem:

The Brahmaputra and the Barak are the two main rivers in the State of Assam. Both rise and outfall outside the boundaries of the State.

Assam is an area of heavy rainfall and high seismic activity. The terrain is hilly, with narrow valleys. The hills are occupied by forests and high lands at the foothills by tea gardens, thus leaving little land in the valleys. Therefore, there is heavy pressure of population on this valley land.

Frequent earthquakes have caused changes in the topographic features and drainage pattern, rise in river beds and land slides. These have resulted in heavy silting in the rivers and consequent aggravation of the flood problem.

The Brahmaputra is a braided river and occupies a width of 6 to 10 km. in the valley which itself is only about 80—90 km. wide. The numerous tributaries, specially those on the northern bank, bring a lot of silt into the river. This results in frequent shifting of their outfalls and heading up of back-waters. The northern tributaries are also prone to avulsions and are not very stable.

Owing to rise in bed levels, heavy silting and backwater effect of the river into its tributaries, drainage is difficult and slow. This results in prolonged flooding of marginal areas and depressions in the valley.

There is a large seasonal variation in the flows of the Brahmaputra river and its tributaries. The heavy silt load results in cross-channels and formation of shoals and bars, braiding and erosion of banks. The bank soil is friable with little clay content, and so easily eroded.

Thus, the major problems in the Brahmaputra basin are:—

(a) overbank spilling from the river and its tributaries.

(b) drainage congestion.

(c) erosion and silting in an unpredictable manner.

The Barak basin lies to the south of the Brahmaputra valley and the width of the valley between the foothills is almost 40—50 km. The level of the river is higher than that of the surrounding valley which is dotted with depressions termed 'haors', the hills bordering the valley are subject to heavy precipitation.

A flood in the Barak river overspills its banks, and heads up into the tributaries and drainage channels thus filling up the 'haors' and the valley floor almost up to the foothills. Heavy rain in the surrounding hills also results in the flooding of the valley.

Thus, the main problem in the Barak valley is inundation from river spills and drainage congestion.

Previous committees/experts:

The High Level Committee, 1957 suggested construction of embankments, improvement of drainage system, anti-erosion, river training and drainage works on the Brahmaputra river. They also suggested construction of storages on the tributaries wherever viable.. Watershed treatment was suggested as the basic remedy.

In the case of the Barak riverr suggestions were made for the improvement of drainage and cut-offs to improve channel conditions.

The Ministers' Committee on Flood Control, 1964 laid stress on investigations for storages and implementation of soil conservation measures.

The erosion problem of the Brahmaputra river being very acute, the Government of India set up a Study Group in 1964. Mr. H. E. Weller of the U.S. Army Corps of Engineers was invited and he visited the State a number of times. In his report he observed that even though it was desirable to have a comprehensive scheme for the control of erosion on the Brahmaputra by means of reservoirs, training works, embankments and spurs, etc., it might not be feasible to implement the scheme on account of technical and other considerations. He, therefore, recommend that anti-erosion works may be carried out in reaches where the problem is acute.

Measures taken so far:

The Brahmaputra river originates in Tibet and most of its length is in that region; the outfall to the sea is in Bangladesh. Also, the tributaries rise in States other than Assam. These factors reduce the range of measures which could be taken by the State. The measures taken so far are embankments, drainage channels, additional drainage suices through embankments, town protection works, and, anti-erosion works specially at concave bends in the river and its tributaries.

The up-to-date, progress achieved in each river system is as below:—

	Brahmaputra	Barak
Embankments .	3131 km	610 km
Drainage channels .	464 km	225 km
Town protection works	32 Nos. (5 major, 27 small)	5 Nos.
Sluices .	368 Nos.	5 Nos.

The total amount spent upto 3/78 is Rs. 76.30 crores.

In the absence of sufficient hydrological data, the flood levels for the design of embankments had to be assessed on the basis of judgment; these levels were exceeded in subsequent years. All the same, the embankments, so far constructed, have been of help and have protected areas from low and medium floods, during high floods, there have been large scale breaches. Gaps for locating sluices left in embankments, particularly in the Barak Valley, have reduced the effectiveness of the embankments.

The existing drainage sluices have given limited relief because the number is insufficient and they are effective only at relatively low stages of flow.

Five-Year Plan 1978—83

In view of the foregoing remarks, the main emphasis during the above Plan has been laid on continuing the following items of work:

(a) Raising and strengthening of the existing embankments where necessary and construction of new lengths.

(b) Anti-erosion works and river channelisation where embankments are under attack.

(c) Town protection works where needed.

(d) Addition of drainage channels and sluices.

(e) Construction of platforms on high ground for use by villagers during floods.

(f) Collection of hydrological data.

The following two additional items are proposed to be taken up in the Brahmaputra basin:

— Continuing investigation of Dehang and Subansiri projects.

— Construction of Pagladiya Detention Dam Project.

Future programme envisaged by the State

(i) The Brahmaputra carries about 32 per cent of the water-resources of the country; the requirements of water and power within the valley, however, are rather limited. There is, however, high potential of hydro-power generation which can be used within and outside the State.

Investigations for multipurposes projects on the Dehang and the Subansiri in the Brahmaputra basin were undertaken some years ago and the feasibility reports are expected. These two dams would moderate the floods as well as generate large blocks of power. There are also a number of dam sites on other tributaries, which have been suggested, but investigations have not been undertaken so far. The sites of some of these dams are located in Bhutan and the adjoining States of Arunachal, Nagaland, Meghalaya; this needs time for achieving coordination and agreements.

In order to reduce the quantum and period of flooding in the Barak valley, a storage in the head reach is considered necessary. Investigations at Tipaimukh site are in progress.

(ii) The following items are proposed to be continued:—

(a) stabilisation of the existing works by way of raising and strengthening of embankments.

(b) construction of new embankments where unavoidable.

(c) anti-erosion measures and river channelisation specially at bends.

(d) improvement of drainage network and construction of sluices where necessary.

(e) change in agricultural practice and crop pattern so as to avoid the flood season.

(iii) The following are proposed to be undertaken:—

(a) surveys to study the behaviour of the multi-channels which keep forming in the braided length of the Brahmaputra river. The idea is to treat the braiding channels at the start rather than to let them develop to damage-causing proportions.

(b) providing raised platforms or raising the villages.

(c) closing gaps left in the Barak embankments and providing adequate number of sluices.

Suggestions

(i) The finalisation of proposals regarding the dams on the Dehang and the Subansiri in the Brahmaputra valley and Tipaimukh on the Barak should be expedited and if the projects are found technically feasible and economically viable they should be taken up for early construction. These will help in arresting silt, moderating floods, generating large blocks of power and inter-basin transfer.

(ii) The case study of the Puthimari embankment indicates that some tributaries in Assam are of aggrading nature, and carry coarse grades of silt and sand which are deposited on the beds and the banks, thus raising the level of the stream above the countryside. Such a situation is very dangerous, as when the embankment breaches the countryside will be devastated with floods. Therefore, before undertaking construction of new embankments, the physical characteristics of the rivers should be carefully examined and alternatives other than jacketing of the rivers seriously considered.

It may be that in a number of locations "living with the floods" by way of providing raised villages and changing of cropping pattern etc., may be the best solution.

(iii) owing to the aggrading river beds being higher than the surrounding valleys, the flood damages, whenever they occur, are heavy. It is advisable, therefore, to regulate future developments, specially in valleys which are highly prone to floods.

(iv) It is noticed that embankments are placed too near the river banks in order to protect as many villages as possible. This leads to the necessity for further anti-erosion works which are expensive and without a guarantee of permanent safety of the embankments. It is, therefore, suggested that in order to minimise the danger of erosion and breaches, the location of, and, spacing between, embankments, should, as far as possible, be in conformity with design requirements.

(v) Anti-erosion works are expensive. In case of danger to long lengths of embankments, it is usually more economical to adopt the alternative of retirement which may, therefore, be considered as a competitive alternative to anti-erosion works.

(vi) Parts of the watersheds of the Brahmaputra and the Barak lie in other States; also shifting cultivation is practised in these watersheds. It is therefore necessary to arrange for coordinated soil conservation measures in those States also.

The probable storage sites on the Barak and the tributaries of the Brahmaputra are likely to submerge areas in other States. An overall study of the problem is needed to assess the areas likely to come under submergence, and the type and extent of development which may be allowed therein.

(vii) The total flow in the Brahmaputra river is more than what can be harnessed or utilised in the valley. On the other hand, there is water shortage in the adjoining Ganga basin. An inter-basin transfer of water to the Ganga basin will help flood moderation in the Brahmaputra basin on account of the storages which will be needed to regulate such a transfer. Such a transfer is under discussion with Bangladesh. It is suggested that the proposal may be finalised and brought to fruition at an early date.

14.27.2. *Manipur*

The problem

The Manipur valley which is about 2230 sq. km. in area (1/10th of the total geographical area of the State) sustains about 75 per cent o the total population of the State. Out of this about 600 sq. km. are occupied by about half a dozen lakes situated south of the capital town of Imphal in the eastern and the western sides of the Imphal river.

The State is drained by two major river systems—the Barak system in the western part of the State and the Imphal (Manipur) system in he central portion. The latter has ten tributaries. The lakes situated in the Manipur valley are also drained through the Imphal system.

The flood problem in the State can be stated as:—

(i) heavy and unusual rains.

(ii) siltation and inadequacy of the river sections.

(iii) deforestation in the upper catchment of the rivers.

(iv) lack of proper drainage system in some areas.

(v) a rocky hump on the Manipur river about 5 km. downstream of Sugnu induces backwater effect for a substantial length in its upstream reach, causing submergence of the adjoining low lying areas.

Measures taken so far

Some nominal flood protection works in the form of embankments in vulnerable places were constructed in the valley up to 1966. Only after the devastating flood of 1966, the need for execution of flood control works in a systematic manner was felt. Accordingly, flood control works were initiated during the Third and subsequent Five Year Plans. In addition to construction/strengthening of flood embankments, improvement of drainage system and, construction of drainage channels were initiated for overall improvement of the flood problem. About 250 km. of embankments have been constructed in the valley upto the end of 1975-76 with a total investment of Rs. 180 lakhs.

Five Year Plan 1978—83

The State has proposed an outlay of Rs. 550 lakhs for the programme during the above Plan. The programme comprises schemes for embankments, drainage channels, sluices, rives training and erosion control. It is also proposed to provide additional storage capacity in some of the multipurpose dams. The Working Group while recommending the provision of Rs. 550 lakhs, desired that preparation of a long-range plan should be taken up and that the schemes taken up for execution should conform to this Plan.

Future programme envisaged by the State

It has been stated by the State Government that a broad plan for construction/improvement of embankments along the Imphal river system has been drawn up for both the banks and is being implemented in a phased manner. The existing works are being treated by the State Government as the first phase to be followed by other measures like construction of storage reservoirs in the upper reaches of the Imphal, the Iril, the Thoubal, the Khuga and the Chakpi rivers as a lasting solution of the flood problem of the valley. Also, diversions of rivers to bypass some of the thickly populated areas and improvements in the drainage system of the valley are contemplated.

Soil conservation, flood forecasting, enlisting cooperation of the local population for supervision of embankments and removal of encroachments within the embankments are also under consideration.

Suggestions

(i) The Thoubal multipurpose project should be taken up and completed early.

(ii) Investigations for reservoirs on the rivers Khuga, the Imphal, the Iril and the Chakpi should be taken up in a systematic manner in order to ascertain the feasibility of suitable multipurpose projects.

(iii) Watershed management, soil conservation and afforestation measures in upper catchments of rivers should be undertaken as of priority in order to reduce silting of river channels. Works for controlling bank erosion specially in steep streams are very costly and should be taken up only in exception circumstances.

(iv) The Sugnu rocky hump mentioned under "The Problem" above is about 20 km. downstream of the Ithai diversion barrage which serves the Loktak hydel power station. It is understood that there is a proposal to remove this hump, thus reclaiming about 57,000 acres (23,000 hectares) by lowering the water level by about 6 ft. (1.8 m). This would amount to about 30,000 acre ft. (37 m. cu m) of water. The Loktak power channel is designed for a maximum discharge of 2100 cusecs (59.47 cumecs). There is an irrigation project drawing about 600 cusecs (17 cumecs) from the lake above the Ithai barrage.

The lowering of the hump may, thus, result in loss of water which could perhaps meet important future needs. We, therefore, recommend that before taking a decision about lowering of the Sugnu hump, a detailed study of the total hydrology of the basin, including the inter-basin transfers, be made to assess the final picture that may emerge after the construction of upstream reservoirs on the river and tributaries and full development of irrigation and hydropower in the valley.

(v) Jacketing of the rivers in long lengths may create drainage congestion behind embankments while raising flood levels in downstream reaches. Therefore, the proposals for storage, embankments and drainage should be considered in an overall design and implemented in a pre-determined sequence.

14.27.3. *Tripura*

The problem

The State is like a central plateau from where numerous small streams flow to the north, the south and the west, ultimately joining the bigger tributaries in Bangladesh. The main rivers of the State flowing north are the Khowai, the Dholai, the Manu and the Juri. The west flowing rivers are the Gumti, the Hoara and the Burigang. The southern flowing river is the Muhari. There are a number of small towns like Khowai, Kamalpur, Kailashahar, Dharmanagar, Sabroom, Belonia and Agartala which are situated near the international border on the banks of these rivers. The rivers near the border are of meandering nature and cause erosion on their concave bends.

The main flood problem in the State can be summarised as under:—

(i) breaching and overtopping of embankments.

(ii) spilling of rivers during heavy floods.

(iii) bank erosion due to the meandering nature of the rivers.

Measures taken so far

Several minor flood control measures have been undertaken in the State. After the floods of 1976, the State Government increased the tempo of work in a more planned way.

Upto the end of the Fifth Plan, the State Government have constructed about 40 km. of embankments, 5 nos. of town protection works, and 94 km. of drainage channels, benefiting an area of 11,100 hectares. During the year 1978-79, an additional length of 12 km. of embankment and one town protection work were undertaken for providing benefit to an area of 1500 hectares.

Five Year Plan 1978—83

The State proposed an outlay of Rs. 550 lakhs for the Five Year Plan. The works proposed included embankments, drainage channels, erosion control and surveys and investigations. The Working Group has approved the outlay as proposed by the State.

Future programme envisaged by the State

The major problems identified by the State are as under:—

(i) Spilling of Hoara river on National Highway No. 44 near Agartala and drainage congestion problem of Agartala.

(ii) Inundation of Kailashahar town by river Manu and Lakshmichera.

(iii) Drainage congestion of Khowai town.

(iv) Erosion of Kamalpur town by river Dholai.

(v) Erosion at Belonia town by river Muhari.

(vi) Erosion of Sabroom town by river Manu.

The problems in other areas are of localised nature and affect comparatively small areas.

Suggestions

(i) For tackling the problem of spill of the river Hoara on National Highway 44 near Agartala, the possibility of diverting Debtagang, a tributary of the Hoara to Katakhal (another natural channel near the town) may be investigated.

(ii) For the problem of drainage congestion within the capital town of Agartala, some pumping arrangement may be required to drain out waters from low lying areas.

(iii) Raising and strengthening should be undertaken for existing embankments protecting towns.

(iv) Anti-erosion measures may be taken for protection of towns threatened by erosion.

Enough space is not usually available for construction of anti-erosion works where a stream passes through a town. Revetments are the best strategy for such locations.

(v) Deforestation and shifting cultivation by the tribal population should be controlled in order to reduce sediment load in rivers.

(vi) Most of the problem in the State is in towns which are situated on the banks of rivers which are prone to flashy floods. As such setting up of a flood forecasting and warning system should prove useful.

14.27.4. *Nagaland and the Union Territories of Arunachal Pradesh, Meghalaya and Mizoram*

The problem

These are heavily wooded hilly areas, where the main problem is deforestation, shifting cultivation and construction of developmental works like roads etc., resulting in sediment being washed down into the rivers, causing clogging of the channels and bank erosion.

Suggestions

(i) The practice of shifting cultivation should be severely curbed and substituted by watershed management and more stable farming.

(ii) Whenever a hillside is disturbed by works like road making, stone quarrying etc., the slope should be property stabilised by a revetment and provision of proper drainage etc.

(iii) Anti-erosion works specially in steep streams are generally costly and should be undertaken in exceptional circumstances.

(iv) Protection needed to some towns and embankments in Meghalaya may be undertaken.

14.27.5. *Sikkim*

The problem

Sikkim is a Himalayan State with the total area to about 73,000 sq.km. of which only about 40 per cent is habitable.

The State is drained by the Teesta and its tributaries. Rising in the steep hills, the river and its tributaries are subject to flash floods after spells of heavy rainfall. The formations of the hills and the banks are sedimentary in nature and are, therefore, susceptible to landslides and heavy bank erosion. The main problem, therefore, is of erosion of banks, which affects scarce agricultural land, towns, and habitations situated on the banks.

Suggestions

(i) The protection of towns of Ranipul, Singtam and Rangpo against river erosion needs priority attention.

(ii) The main highway passes along the banks of the river Teesta. The cutting of the road has resulted in the hill slopes becoming unstable at certain places. these require stabilisation and protection.

(iii) Anti-erosion works, specially in steep streams, are generally costly and should be undertaken in exceptional circumstances.

14.27.6. *North Bengal*

The problem

The flood problem in North Bengal is distinctive from that in Central and South Bengal in that while the former area suffers mainly from problems arising from heavy silt loads and flash floods, the latter areas are afflicted mainly with drainage congestion.

The main rivers of the Brahmaputra basin are the Teesta, the Jaldhaka and the Torsa and their tributaries. Rising in Sikkim and Bhutan, except for the Torsa which rises in Tibet, these rivers cascade down the hilly slopes before entering North Bengal. The Himalayas are a young sedimentary formation and, therefore, easily erodable. Furthermore, the hills are in the seismic zone and subject to frequent landslides. Also the practice of shifting cultivation is widely practised and wide scale deforestation takes place on account of the needs of the increasing population.

By the nature of things, these rivers bring down a substantial amount of sediment and debris. Reaching the plains the river slopes become flatter and the sections wider, which results in deposition of silt, overspilling and change in river regime. Thus the flood problem may be stated as under:—

(i) heavy flows due to flash floods caused by intensive rainfall;

(ii) sedimentation, avulsion and changes of river regime;

(iii) spilling over banks and flooding valley areas which are relatively lower in levels;

(iv) bank erosion and tendency to meander of the rivers;

(v) changes in the river course;

(vi) sand casting during flood; and

(vii) soil erosion in the upper watersheds.

Previous committees/experts

Following the unprecedented floods of October 1968, an Expert Committee with the Chairman of the then CWPC as Chairman and representatives of the concerned Ministries and Departments was constituted to examine the problem and suggest remedial measures. The Committee recommended, amongst others, soil conservation in the upper catchments, extension of waterways of cross drainage works, construction of embankments, river training works where necessary, strengthening of the embankments for the protection of Jalpaiguri town and improving the flood warning system.

Measures taken so far

To deal with the flood problem, master plans for five major rivers were prepared in 1965-66. These include items like soil conservation and check dams etc., in the hill catchments and embankment and anti-erosion works in the plains. These master plans are under review.

In order to facilitate prompt and effective action towards formulation and implementation of a flood control plan, the State Government has set up the North Bengal Flood Control Commission, which started functioning from November 1971. The Commission has prepared a master plan for the Torsa basin; this is under scrutiny in the CWC.

The measures taken so far comprise mainly protective works for the towns of Jalpaiguri, Coochbehar, Alipur Duar, Mathabhanga and Siliguri; embankments along the rivers Teesta, Diana, Jaldhaka and Torsa and training of the river Gubur Barsa.

Suggestions

(i) severe control on the practice of shifting cultivation and proper watershed management in the upper catchments;

(ii) stabilisation of hillside slopes wherever they are cut for construction of works like roads etc.

(iii) updating of master plans for the five major rivers.

THE GANGA BASIN

14.28. The Ganga Basin

The basin is bounded on the north by the Himalayas and on the south by the Vindhya mountains. The river flows almost north-west to south-east. The region covers partially or fully the States of Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal and the Union Territory of Delhi. The first four and the State of West Bengal form geographical parts of other river basins also. It is not, however, possible to split up the States into the relevant units for the present purpose. Therefore, the last three States have been included under he Ganga Basin, but each State has been dealt with in a composite manner. The North-western Rivers Basin is more therefore, been dealt with under that Basin. In important for Himachal Pradesh, which has, West Bengal, the flood problems are distinct in North Bengal which lies in the Brahmaputra Basin. North Bengal has, therefore, been dealt under that Basin; Central and South Bengal are covered under the Ganga Basin.

The Ganga has a large number of tributaries, both from the north as well as from the south, the important ones are the Yamuna, the Ramganga, the Gandak, the Sone, the Kosi, the Ghaghra the Damodar/Rupnarayan etc. The northern tributaries rise in the Himalayas which have a loose soil mantle; as such they bring down a lot of silt. The southern tributaries traverse more stable courses and to that extent do not contribute as much silt as the northern ones.

The area receives the total annual rainfall in about 3 to 4 months during the monsoon season; heavy and intensive falls result in floods. A significant contribution to the total volume of river flows is from the snows from the Himalayas; the extent of the contribution to floods is not quite known.

A lot of deforestation has taken place and still continues in the Himalayas. This results in soil erosion and silt loads in the rivers as also reduction in sub-soil water storage due to which the stream flows in the fair season are getting reduced.

The main problem is overspilling of banks, silt deposition, changing of river courses, drainage problems in flat areas, specially depressions and tidal lockage in the outfall reach to the Bay of Bengal. Erosion of banks also poses problems at places.

There are a number of sites for storages on the tributaries of the Ganga; many of them in Nepal. Storages are useful in moderating or controlling of floods. Supplying regulated flows for irrigation and hydro-generation and trapping of silt would be added advantages.

Watershed management and soil conservation would form an important complementary programme to construction of storages, reduce soil erosion and increase fair weather flows in streams. Development of storages, coupled with watershed management and soil conservation measures in Nepal would benefit both countries.

14.28.1. *Haryana*

The problem

The State can broadly be divided into two tracts, namely, the Ghaggar and the Western Yamuna tracts.

Rising in the Sivaliks, and traversing the States of Punjab and Haryana, the Ghaggar tails into Rajasthan. In the past, this river used to vanish into sandy areas. The river is joined by three important tributaries *viz.*, the Tangri, the Markanda and the Saraswati. Owing to intensive Irrigation, a number of drains which have been constructed in the States of Punjab and Haryana, outfall into the Ghaggar river; this is a cause contributory to the river now becoming alive. During the monsoon season, the Ghaggar, the Tangri and the Markanda spill over their banks.

The Yamuna is an important tributory in the Ganga basin; the Sahibi Nadi rising in Rajasthan is an important tributory of the Yamuna and has become active in the last few years. The Sahibi Nadi did not have any proper outfall, but, of late, it has been draining upto the border of Delhi through Drain No. 8 of Haryana and then into the Yamuna through Najafgarh Drain.

During floods, the Ghaggar and the Sahibi Nadi spread over large areas of land which are damaged; villages are also affected as there are frequent changes in the river course. The National Highway No. 8 and Delhi-Rewari railway line are also affected by floods in the Sahibi Nadi.

The main problems may, therefore, be stated as under:

(i) Accumulation of spill waters from the rivers for long periods in depressions.

(ii) Inadequate drainage system.

(iii) Inadequate waterways under roads, railways, irrigation channels, etc.

There is also the inter-State aspect with the adjoining States of Uttar Pradesh and Rajasthan and Union Territory of Delhi, with regard to drainage waters passing across the border and through these areas.

Previous Committees/experts

Appointed by the State

The Committee appointed by the then Government of Punjab after the floods of 1955, identified the causes of floods as inadequate drainage system and insufficient waterways under roads, railways and irrigation channels; spills from the rivers; lack of storage dams on rivers and denudation of hills.

Amongst the more important recommendations of this and the other committees are items of improvement in the drainage network, construction of a dam on the Sahibi Nadi, improvement of Najafgarh Drain in Delhi territory, increase in waterways under existing bridges, etc.

Appointed by the Centre

The High Level Committee, 1957, examined the recommendations of the Ganga River Commission for the then State of Punjab, and recommended the following:—

(i) The capacity of existing drains should be improved and the obstructions in the course of drainage channels removed.

(ii) Waterways under bridges and culverts should be improved wherever inadequate.

सत्यमेव जयते

(iii) Embankments on the Yamuna should not be constructed as they would worsen the situation at Delhi.

(iv) One or more dams on the river Yamuna and/or its tributaries should be constructed, after proper investigations.

After the disasterous flood of 1977 in the Sahibi Nadi and Najafgarh Drain in Haryana and Delhi, a Committee of Direction under the Chairmanship of the Chairman, CWC and a Working Group under the Chairmanship of Member (Floods), CWC, were appointed to prepare a comprehensive master plan for the utilisation of water resources, flood control and drainage in the Sahibi Nadi and Najafgarh drainage basin. The master plan has since been approved by the States of Haryana and Rajasthan and the Union Territory of Delhi and comprises construction of a storage on the Sahibi Nadi at Ajmeripura in Rajasthan and a barrage at Masani in Haryana. It also visualises improvement of the Najafgarh Drain in Delhi and the drainage system in rural areas of Haryana and Delhi, construction of ring bunds to protect isolated villages, and construction of small tanks/bunds in the upper catchments in addition to flood plain zoning.

The Working Group on Integrated Action Plan for Flood Control (in Indo-Gangetic Basin), 1978, examined the problem. The important recommendations are construction of storage reservoirs on the Sahibi Nadi and soil conservation and watershed management in the basins of the Yamuna and the Sahibi Nadi.

Measures taken so far

A large mileage of embankments has been constructed along the Ghaggar and its tributaries, *viz.*, the Markanda and the Tangri. Also, substantial mileage of drainage channels has been constructed. The Chautang Nala has been channelised and the Saraswati drain constructed to guide the waters from the Bibipur Lake, which is the outfall of the Saraswati Nadi, into river Ghaggar.

Anti-erosion measures have been taken to protect marginal embankments on rivers as also to protect agricultural areas and villages. Ring-bunds have also been provided round isolated villages.

Five Year Plan 1978—83

The State had earlier indicated a master plan for Rs. 138 crores; in their proposals for the above plan, they have indicated the revised estimated cost of works proposed as Rs. 152.62 crores. Some of the schemes prepared relate to construction of storage/barrages which will be primarily utilised for irrigation giving subsidiary benefits to flood control; only the costs chargeable to flood control are stated to have been included under the "flood" sector. Some of the other works proposed are construction of drains, increasing the capacity of existing drains, construction of ring-bunds, remodelling of drains, surveys, investigation and preparation of master-plan, and, monitoring. The Working Group has recommended an outlay of Rs. 130 crores for the Five Year Plan. The Working Group has suggested that works being undertaken by the State in the Yamuna, the Sahibi, the Ghaggar and other basins are likely to have inter-State repercussions; the schemes in these basins should, therefore, have the approval of Standing Committees like the Yamuna Committee, the Sahibi Committee and the Ghaggar Committee.

Future programme envisaged by the State

The State had prepard a so-called master plan estimated to cost Rs. 138 crores (revised estimate Rs. 152.62 crores) including areas in the Ghaggar basin. These provide for relevant items like new drains, link drains, reservoirs and barrages and ring-bunds around villages etc.

The main items proposed are—

(i) Ujjina diversion drain.

(ii) Remodelling and strengthening of Diversion Drain No. 8.

(iii) Construction of link drains in various districts,

(iv) Construction of barrages on the Sahibi, the Tangri and the Markanda,

(v) Ring-bunds round villages,

(vi) Strengthening of embankments, and

(vii) Small storage tanks in depressions.

Suggestions

(i) Embankments are being constructed on both banks of the Yamuna by the States of Haryana and Uttar Pradesh as also by the Union Territory of Delhi. Extensive embankments along the river will cut off large valley storage, resulting in increased flood peaks which will become a source of danger to Delhi. We reiterate the advice given by the High Level Committee, 1957, that embankments should not be constructed in an unbroken length along the Yamuna. We suggest that this matter be given serious consideration by the States and the Centre and necessary steps taken to ensure that the embankments are so constructed as to leave reasonable valley storage.

Wherever the embankments are constructed, they should, at least for agricultural areas, be designed for a low frequency of floods like a 25-year frequency. Spillways/breaching sections should be provided and actually operated when the flood reaches a level higher than designed.

The embankments should be planned on both banks of the river, the spacing between the river edge and the embankment conforming to design requirements as far as possible.

(ii) We recommend execution of the comprehensive plan for the Sahibi Nadi including the dam at Ajmeripura in Rajasthan and the barrage at Masani in Haryana.

Reservoirs/barrages are also recommended on the Ghaggar, the Tangri and the Markanda.

(iii) We also recommend execution of watershed management and soil and water conservation measures in their catchments.

(iv) There has been a tendency to reclaim lands from natural depressions, which usually act as balancing reservoirs during floods. Before taking such measures, the overall position should be carefully considered and the balancing storage in depressions retained as far as possible.

(v) Flood plain zoning regulations are very useful measures and should be adopted as far as practicable.

(vi) Improvement of overall drainage should be investigated and undertaken. Care should be taken that the drainage is taken up to the outfall point in the river and not left at a location where it might flood other areas.

In this connection, Ujjina Diversion drain would help solving the inter-State problem of the Pahari-Kama-Goverdhan Drain and we recommend execution of the same.

We also recommend a supplementary drain taking off from the Sahibi Nadi upstream of the proposed Masani Barrage and outfalling direct into the Yamuna river, south of Delhi.

(vii) Rajasthan, Uttar Pradesh and the Union Territory of Delhi are likely to be affected by some of these measures. It is, therefore, recommended that proposals have the approval of the Yamuna, the Sahibi and the Ghaggar Committees' which have been set up to coordinate measures in these areas.

14.28.2. *Delhi*

The problem

The lie of land in the Union Territory of Delhi is mostly flat. There is a big depression (Najafgarh jheel) in the south west of the territory adjoining Haryana. The topography of the territory is such that it receives drainage waters from the adjoining States of Haryana and Rajashtan. The only outlet for evacuation of these waters is the river Yamuna.

Due to the construction of embankments on both the banks of the river in almost the entire reach in the Union Territory, the problem of floods due to the spills of the Yamuna has been very much reduced except in a small area downstream of Okhla. There are, however, pockets of habitations which continue to remain inside the embankments and are, therefore, affected by almost every flood.

For the evacuation of excess storm waters from the areas in Haryana and of the Sahibi Nadi, the only outlet is the Najafgarh drain which starts from the Dhansa Band and discharges into the river Yamuna downstream of the Wazirabad barrage. Due to the rapid pace of urbanisation in the capital and also drainage improvements being carried out in the adjoining State of Haryana, the flow in the Najafgarh drain has been on the increase during the last few years so much so that the drain is not in a position to speedily evacuate these flows; this leads to drainage congestion in the tributary drains and the adjoining areas.

The trans-Yamuna colony of Shahdara is, in parts, low lying area. Whenever the Yamuna is in high stage during the flood season, it is not possible to drain off this area into the river by gravity.

The problem in the territory thus comprises:

(i) spills from the river Yamuna,

(ii) drainage congestion during the periods of concentrated heavy rainfall,

(iii) flooding and drainage congestion on account of waters from drains of Haryana and from the catchment of the Sahibi Nadi entering Delhi.

Previous committees/experts

Following the flooding of large areas due to heavy precipitation in 1958 and damage to roads and buildings, the Reddy Committee was appointed for plainning measures against floods and similar calamities in the capital. The Committee recommended norms for design of storm water drainage in the urban as well as rural areas. The Committee also recommended raising and strengthening of some bunds and shifting of villages which were located between the bunds and the river.

Following serious floods, Motiram Committee was appointed in 1964 to make a scientific assessment of the problem in Delhi and neighbouring areas and suggest a comprehensive scheme for flood control. Amongst others, the Committee recommended increasing the capacity of the Najafgarh Drain from 3000 cusecs (85 cumecs) to 10,000 cusecs (283 cumecs) in the tail reach, so as to suit further development; increasing the capacity at Dhansa Bund to 3000 cusecs (85 cumecs) and approaching the adjoining State (then Punjab) for construction of small storage dams on hill tributaries of the Sahibi Nadi. The Committee further suggested a unified authority of control and operation of flood regulation amongst areas of the Union Territory and the concerned State (now Haryana).

Considerable damage was caused in the Union Territory of Delhi during 1967. The J. P. Jain Committee was set up to make necessary studies and suggest remedial measures. Its recommendations included increasing the capacity of the Najafgarh Drain, construction of a supplementary drain, raising of the Dhansa Bund, construction of a reservoir at Ajmeripura in Rajasthan and check dams in the Sahibi catchment.

The Working Group and Committee of Direction appointed in 1977 under the Chairmanship of the Chairman, CWC, for preparing a master plan for the Sahibi Nadi and Najafgarh Drain has, as far as Delhi is concerned, recommended strengthening of Dhansa Bund, improvement of Najafgarh Drain, construction of a supplementary drain taking off from upstream of Masani Barrage and outfalling direct into the Yamuna south of Delhi and flood plain regulation.

The Working Group on Integrated Action Plan for Flood Control (in Indo-Gangetic Basins), 1978 has recommended drainage works and embankments as also water-shed management in the catchment of the Yamuna-Sahibi.

सत्यमेव जयते

Measures taken so far

The river Yamuna in the Union Territory of Delhi has been embanked on both its sides almost in the entire reach except a small area downstream of Okhla, thus affording reasonable protection to the city from the spills of the river Yamuna. Similarly, for catering to the problem of storm water drainage from the rural areas, a network of drains have been constructed. For the drainage from the urban areas, the Najafgarh drain which was originally designed with a capacity of 900 cusecs (25.5 cumecs) to cater mainly to the discharge from the rural areas is now being remodelled to a capacity of about 10,000 cusecs (283 cumecs) within the city limits. At present, drainage water in the trans-Yamuna area is pumped into the river. The Shahdara Drainage Scheme, which will ensure disposal by gravity downstream of the new Okhla barrage, has been taken up.

Five Year Plan 1978—83

Details of the Plan are not yet available. The Working Group on Flood Control headed by the Secretary, Department of Irrigation, however, has proposed an outlay of Rs. 60 crores for the flood control sector during the period 1978—83. The important schemes suggested are as under:

(i) Improvement of the capacity of Najafgarh Drain from Dhansa to Bharatnagar Bridge to 8,000—10,000 cusecs (226.5—283 cumecs).

(ii) Scheme for raising and strengthening of existing embankments on the river Yamuna.

(iii) Improvements in the discharge capacity of a number of drains.

(iv) Construction of a supplementary drain to reduce pressure on the Najafgarh Drain.

Suggestions

(i) Though technically not quite advisable, embankments on the Yamuna are being constructed by the upstream States of Uttar Pradesh and Haryana, thus cutting off valley storage with consequent raising of flood levels. The safety of embankments for the urban areas should, therefore, be constantly reviewed against the increasing flood levels.

(ii) To minimise the extent of progressive rise in flood heights, it is suggested that in concurrence with the adjoining States, the embankments in the upstream reaches of the Union Territory, where they protect predominantly agricultural areas be designed for a 25-year frequency flood only. Spillways/breaching sections should be provided and actually operated when the flood waters reach a level higher than designed.

To avoid serious damage, developmental activities in the flood plains should be regulated.

(iii) Depending upon the damage potential, protection to urban areas should be provided for a 100-year or the maximum observed flood; protection against the maximum probable flood would be justified for cities like Delhi.

(iv) The solution, though partial, to stop the progressive embanking of the river, lies in the construction of upstream reservoirs, with flood space where possible, on the Yamuna and the Sahibi Nadi and their tributaries.

The reservoir sites are located in the adjoining States. In the interest of the capital of the country, however, steps should be taken to expedite investigations and construction of these reservoirs as early as possible.

(v) The Master Plan for the Sahibi Nadi prepared by the Central Water Commission may be taken up for implementation in coordination with the States of Haryana and Rajasthan.

Similarly, processing the Master Plan for improvement of storm water drainage system in the Union Territory of Delhi prepared by the Delhi Administration may be expedited.

14.28.3. *Rajasthan*

The problem

Rajasthan is an arid area with a very low rainfall which has resulted in the establishment of desert topography with a thick mantle of sand. The State lies in the basins of the Indus (North-western Rivers Basins), the Mahi (the Central India and Deccan Rivers Basins) and the Ganga, the last through its tributary the Yamuna.

The only important river in the Indus Basin is the Ghaggar, which has been described in para 14.28.1 *ante.*

The Luni, the Mahi and the Sabarmati fall in the Central India and Deccan Rivers Basins. The Luni rises in the Aravali hills, flows in south-westerly direction and outfalls in the Rann of Kutch in Gujarat. The river is usually dry, but is subject to occasional flash floods like the one that occurred during 1979 and damaged large areas. The Mahi and the Sabarmati also flow into Gujarat, these rivers present no flood problems.

The Chambal and its main tributaries the Banganga and the Gambhiri, as also the Sahibi Nadi, join the Ganga through the Yamuna. The Chambal has no flood problem, except local bank erosion here and there. The Banganga and the Ghambhiri flow through the flood plain of Bharatpur district, and cause drainage congestion in that area. The Sahibi Nadi originates in Rajasthan and flows through Haryana. It used to get absorbed in sandy areas, but has now become active and outfalls into the Yamuna through Drain No. 8 and Najafgarh Drain. It spreads overland in Haryana and floods large areas.

The State has also a problem of drainage which it shares with Haryana and Uttar Pradesh through the Pahari-Kama-Goverdhan Drain.

Due to lack of rainfall, dry climate and sandy soil, the area is by and large devoid of vegetal cover. This leads to soil erosion and flash floods. The sediment load in the rivers is also somewhat heavy as for example in the Sahibi Nadi.

The problem, though not very serious, may be summed up as under:—

(i) Flash floods in the Sahibi Nadi in the past few years.

(ii) Soil Erosion.

(iii) Drainage congestion.

Previous Committees/Experts

The High Level Committee, 1957, identified Bharatpur area as prone to flooding. The Committee emphasised the need for collection and compilation of data about minor irrigation tanks, inflow and outflow etc., so that the problem could be studied in detail.

The Technical Committee for the Ghaggar Basin was constituted in 1968 to prepare a coordinated plan of works and the procedure for implementation of the schemes. The Committee has not met since 1970.

The Committee under the Chairmanship of the Chairman, Central Water Commission, to study the flood problem in the Ghaggar river and suggest remedial measures and apportionment of costs amongst the Northern Railway and the States of Rajasthan, Haryana and Punjab, studied the problem during 1968—72. The Committee suggested certain works, such as raising and strengthening of some irrigation channels, providing syphons and adequate waterway under them and providing adequate waterways in Suratgarh-Sarupsar-Roopgarh section of the railway line etc. The recommendations about the sharing of costs between the Railways and the State Governments could not be implemented due to controversies between the Railways and the State Governments.

The Motiram Committee, 1968, suggested the construction of a dam on the Sahibi Nadi for irrigation and moderation of flows mainly for the protection of Delhi area.

The Working Group and Committee of Direction set up after the 1977 floods in the Sahibi Nadi, recommended construction of a dam on the Sahibi Nadi at Ajmeripura, and measures for soil and water conservation in the upper catchments as also construction of minor irrigation tanks in the catchment.

The working Group on Integrated Action Plan for Flood Control (in the Indo-Gangetic Basins), 1978, recommended the construction of the Ajmeripura dam on the Sahibi Nadi, as also soil conservation measures in the Sahibi catchment and drainage improvement in the Yamuna basin.

Measures taken so far

Although started in the Second Five Year Plan, flood control/protection measures were taken seriously only from the Third Plan onwards, about 80 km of embankments and 130 km drainage channels have been constructed and 13 towns have been afforded protection.

After the disastrous floods of 1964, it was decided to divert about 370 cumecs of water from the Ghaggar river and carry them to depressions in the sand dunes of Rajasthan. The scheme has been in operation since 1969 and has benefited areas, specially in Suratgarh.

The State has shared the construction of the Pahari-Kama-Goverdhan Drain with Haryana and Uttar Pradesh.

Five Year Plan 1978—83

The State has proposed an outlay of Rs. 10 crores for the Five-Year period. Amongst the continuing schemes to be executed are the Ghaggar and the Bharatpur flood control works. As far as the new schemes are concerned, the flood control works on the Banganga, the Sahibi and the Gambhir are proposed to be taken up during the Plan period. The Working Group recommended an outlay of Rs. 20 crores for the flood control sector.

Future programme envisaged by the State

Amongst other important proposals framed by the State are dams on the Gambhir and the Sahibi rivers, Ghaggar flood protection works, remodelling of the Pahari-Kama-Goverdhan Drain in the State territory, and providing protection to some towns.

Suggestions

(i) The most important problem is that of the Sahibi Nadi. It is recommended that the dam at Ajmeripura may be constructed.

(ii) Measures should be taken for soil and water conservation and afforestation in the catchments, specially of the Sahibi Nadi in Rajasthan and Ghaggar (and its tributaries) in the States of Punjab and Haryana.

Flood plain regulation would also be a useful measures.

(iii) The drainage capacity of the length of the Pahari-Kama-Goverdhan Drain within the State should be suitably increased in consultation with Uttar Pradesh in whose territory, consequential increase in drainage capacity would be needed.

(iv) Bharatpur city and the adjoining low-lying areas are subject to flooding. The Government is aware of this problem and action towards amelioration is recommended.

(v) Ring bunds may be useful to protect habitations in the catchment of the Sahibi Nadi.

सत्यमेव जयते

14.23.4. *Madhya Pradesh*

The problem

The State is situated in the central part of the country. Almost all the major rivers and their tributaries flowing through Central India have their origin in Madhya Pradesh. To name a few, the Chambal, the Ken and the Betwa drain into the Yamuna and the Tons directly into the Ganga, the Narmada, the Tapi and the Mahi flow towards the west into the Arabian Sea, the Mahanadi flowing through Orissa falls into the Bay of Bengal, the Godavari rising in Maharashtra has also a certain length of the river in this State.

Although the flows in the rivers are of high intensity, their duration is very short. Low-lying areas close to the river banks get submerged occasionally.

In the basins of the Ganga, the Mahanadi and the Godavari, the flood problem is of minor significance and localised in isolated areas.

Floods in the Narmada basin have been due to heavy rains in the recent past. There have been heavy floods causing inundation of some towns and villages in the districts of Hoshangabad, Sehore and Khargone; Hoshangabad town itself was also subject to heavy flooding and damage during the 1973 floods.

Similarly, there were some heavy floods in the Chambal and the Betwa river basins during 1977, affecting areas in certain districts.

The problem, therefore, is not of a persistent nature in any particular area and, therefore, has to be treated by spot works.

Measures taken so far

General types of works undertaken are for anti-erosion and localised protection.

Five Year Plan 1978—83

Under the Plan the State proposed items like collection of hydrological data, protection of towns and villages, repairs and extension of Ghats and research, surveys and investigations totalling Rs. 6 crores.

The Working Group has recommended an outlay of Rs. 5 crores.

Suggestions

The Working Group on Integrated Action Plan for Flood Control (in the Indo-Gangetic Basin), 1978, has recommended a reservoir on the Sone river and soil conservation in general. We support the suggestions.

14.28.5. *Uttar Pradesh*

The problem

For consideration of the flood problem, the State of Uttar Pradesh may be divided into the Hill, the Western, the Southern, the Central, and the Eastern zones.

Major rivers like the Ganga, the Yamuna, the Ghaggra, etc., and their tributaries originate in the Hill zone. Landslides, and erosion of towns, villages and lands on account of very heavy precipitation over the land surface having thin soil cover are the major problems of this zone. Landslides at times block rivers, creating temporary lakes behind them, when the blockages get cleared, sometimes high flash floods result.

The Western zone is drained by the Yamuna, the Ramganga and the Ganga. This zone has the problem of inundation due to spilling over the river banks as well as drainage congestion on account of inadequacy of proper surface drainage. In certain places, particularly in the case of the Yamuna, bank erosion has caused problems.

The Southern zone is drained by the right bank tributaries of the Yamuna, the Tons and the Sone, and, does not have any serious problem.

The Central zone is drained by the Sarda, the Gomti and the Ganga rivers. This region gets affected to a great extent by over-spilling of banks and surface drainage congestion.

The Eastern zone is drained by the Ganga, the Ghaghra, the Gomti and the Gandak. Almost 40 per cent of the total flood damage in the State takes place in this region. Not only the big rivers but also the small tributaries cause havoc and devastation, specially when their floods synchronise. The flood problem comprises inundation of areas due to over-spilling of banks, drainage congestion, and, erosion of towns and villages, sometimes there are serious disruptions of rail and/or road communications.

The Ganga and a number of its tributaries rise in the Himalayas. The Himalayas are of sedimentary origin and easily erodible. Deforestation, landslides and cutting the hillsides for developmental works accentuate the flow of debris into the streams.

A number of large tributaries like the Ghaghra, the Rapti and the Gandak originate in Nepal, then contribute more than 33 per cent of the flow in the Ganga at Farakka. Suitable sites for storages for water resources development and trapping silt lie in that country, so also large upper watersheds where management would reduce washing down of silt in the rivers.

The main problems are as under:—

(i) overspilling of banks and inundation of areas.

(ii) erosion of river banks, villages and towns.

(iii) changes in river regime and courses due to heavy silt loads.

(iv) drainage congestion.

(v) soil erosion.

Previous committees/experts

A number of Committees have reported on one or the other problem of floods in the State.

Appointed by the State

The Flood Enquiry Committee appointed by the State Government after the high floods of 1948, recommended that marooned villages be permanently shifted to high ground, fallow and barren land should either be brought under the plough or reafforested. A proper plan for re-afforestation of catchment areas of rivers should be drawn up, waterways under the culverts and bridges should be increased where necessary, and, a provision for flood control should be included in the projects for multipurpose reservoirs.

Appointed by the Centre

The main recommendations of the High Level Committee (1957) were to improve the drainage systems, remove inadequacy of waterways of bridges, and to shift marooned villages to high ground or raise their plinths or provide ring bunds round them.

The Ministers' Committee on Flood Control (1964), recommended storages, canalisation and other methods of flood control, drainage behind embankments, and, protection of marooned villages.

The Gandak High Level Committee set up in 1971 recommended a number of measures to be taken on the Gandak river, in pursuance of which flood control and river training works have already been taken up and others are in the process of implementation.

The Working Group on Integrated Action Plan for flood Control (in Indo-Gangetic Basin), 1978, has suggested construction, amongst others, of Kishau dam on the Tons, Lakhwar dam on the Yamuna, and Rajghat project on the Betwa. They have noted the existing Indo-Nepal cooperation with regard to water resources development projects on some of the tributaries rising in Nepal and recommended early studies for finalising more joint projects. The group has further recommended soil conservation, afforestation and watershed management in the catchment, mostly in the Himalayas including areas in Nepal.

Measures taken so far

Works, constructed before 1954, were mostly in the nature of embankments, these were undertaken by private agencies or individuals. The only important works, worth mentioning, of that period are:—

(i) the Malony bund on the left bank of the Rapti to protect Gorakhpur town and adjoining areas, and

(ii) the embankment on the left bank of river Tons for protecting Azamgarh town.

The need for undertaking extensive flood protection measures was highlighted by the disastrous floods in 1954. Upto the beginning of the Fifth Plan, the State Government had undertaken execution of a large number of flood protection works comprising marginal embankments along the rivers Ghaghra, Tons, Ganga, Gandak, Rapti and others. Anti-erosion works have also been taken up in some reaches of the rivers Gandak, Ghaghra and Yamuna.

Measures were also taken to protect a number of towns, the more important being Allahabad, Ballia, Varanasi, Lucknow, and Azamgarh. In addition, a number of drainage improvement and new works, mostly in Mathura, Agra, Meerut, Rae-Bareili and in the eastern districts were completed. Another important work undertaken in the eastern region was the raising of over 4,500 marooned villages above high flood levels of the rivers.

These works aggregate to 1,174 km of marginal embankments, 11,953 km of drains, protection to 53 towns and raising of 4,500 numbers of villages. The total expenditure upto the end of March, 1978, is estimated at Rs. 79.40 crores and the area benefited over nine lakh hectares.

Five Year Plan 1978—83

The State has proposed a provision of Rs. 242 crores comprising about Rs. 46 crores for continuing schemes and Rs. 196 crores for new schemes. The following works are planned:

(i) construction of new drains .	2,760 km
(ii) remodelling of existing drains and river improvements	1,580 km
(iii) raising and strengthening of existing embankments .	1,101 km
(iv) new embankments . . .	300 km
(v) town protection	43 Mos

It is anticipated that an area of 13.7 lakh hectares would be benefited.

The Working Group for the Plan has examined the proposals and recommended a provision of Rs. 200 crores. It has also been stated that the drainage works should be undertaken only in non-irrigated areas. Drainage for areas under irrigation projects should be a charge on 'Irrigation'.

In the Plan document of the State, a provision of Rs. 12 crores has been shown against reservoir schemes. In the list of 55 storage schemes attached with their reply to our questionnaire, however, there is none showing any provision of flood cushion or of embankments in conjunction with any storage. It, therefore, appears that these schemes have yet to be properly surveyed and investigated and that the provision is only an approximation.

Future programme envisaged by the State

According to the replies from the State, "the preparation of comprehensive basin plans for optimum and multipurpose utilisation of water resources of the State involves work of very high magnitude. The State has not yet been able to evolve comprehensive plans of flood control". The main difficulties are stated to be, want of hydrological data, basin surveys, investigations of water availabilities and reservoir sites and accuracy of assessment of flood damaged areas and loss.

However, the State has submitted to the Government of India, a basinwise Action plan for the Ghaghra, the Rapti, the Gandak, the Yamuna, the Gomti and the Ramganga basins.

Amongst the problems to be dealt with are spills and erosion in lower reaches of the Ganga, particularly in the districts of Azamgarh, Pratapgarh, Ballia and Ghazipur. The problems of the Yamuna are complicated because it is an inter-State river and there is a continuous problem of uncoordinated construction of embankments and spurs by the States of Haryana, Uttar Pradesh and the Union Territory of Delhi, which affects the river regime and leads to erosion of banks. There is also the inter-State problem of the drainage through the Goverdhan drain involving the States of Haryana, Rajasthan and Uttar Pradesh. In the case of the Gomti, the inadequate waterways on the bridges need to be tackled, as they cause problems for the towns of Lucknow, Jaunpur and Sultanpur. The Ghaghra river affects the districts of Basti, Azamgarh, Ballia, Gorakhpur and Deoria. The Rapti carries heavy silt, which deposits and aggravates drainage congestion in Gorakhpur and adjoining areas. Gaps in the embankments along the Gandak cause problems and need to be filled.

Considering the various problems, the State has proposed the following priorities:—

(i) expeditious completion of on-going schemes,

(ii) schemes for protection of towns and large habitations,

(iii) schemes for areas chronically affected by floods,

(iv) schemes for relieving water-logging and drainage congestion,

(v) reservoir schemes for flood absorption and moderation.

Suggestions

(i) The programme and priorities detailed for the Five Year Plan 1978—83 are likely to take much longer than 5 years. After due investigations and study, these should now be put into shape as overall basin plans, on the basis of which detailed plans and estimates could be prepared. It may take a long time to investigate and plan storages. While taking note of the possibility, preparation of master plans for flood mitigation may not be delayed on that account.

(ii) Under the new schemes, a provision of Rs. 12 crores has been made under "Reservoirs". It is necessary to investigate the feasibilities and decide if there are possibilities of providing a flood component in any multi-purpose reservoir, if so the construction thereof should receive priority.

The headwaters of the rivers Ghaghra, Rapti, Gandak and Sarda (Mahakali in Nepal) rise in Nepal, suitable reservoir sites on these rivers are located in Nepal only. Committees have already been appointed for joint investigations and preparing detailed reports and project estimates for some storages about which negotiations have been in progress between India and Nepal. These should be expedited, even where specific flood storage is not possible, substantial moderation should be aimed at.

A number of sites within the State have also been listed. Systematic investigations and planning should be undertaken urgently in the order of probable quantum of benefits from the "flood" angle.

(iii) It is hardly likely that storages would be fully effective as protective measures, they would, in most cases need to be supplemented by embankments lower down. Investigations for these should be concurrently undertaken.

(iv) The provision of Rs. 5 crores as a start for surveys and investigations is timely. This work will have to continue for a long time for the investigations visualised in (ii) above. Surveys and investigations is a continuous process and provisions should continue to be made in the future Plans also.

(v) A lot of expenditure has been incurred and a substantial provision made for anti-erosion and river improvement works. These works, quite often, appear to consist of protecting individual villages. It is also understood that anti-erosion works are sometimes undertaken to protect agricultural areas between the river banks and embankments. Anti-erosion works are expensive in capital and maintenance costs and should, as a rule, not be undertaken except for protection of valuable installations and towns.

It is doubtful if anti-erosion could be an economicaly viable solution in the case of small and isolated villages. A case study of capital and maintenance costs and effectiveness achieved in the case of a few villages may be undertaken to assess the viability of the method. The alternative of shifting the village may prove cheaper and should be examined in each case.

Embankments are constructed to protect lands and habitations outside the embankments. The areas between the embankments and the river edge have to suffer floods if and when they occur. There can be no justification for undertaking any anti-erosion works for the protection of such land they should be considered only where specifically needed for the protection of the embankments.

(vi) Schemes for relieving water-logging have been included amongst the priorities for the Plan 1978—83. Water-logging is distinct from flooding and relief usually results in land reclamation. Such schemes, should, therefore, not find a place under "flood" Sector.

(vii) Early steps are necessary to create or revamp/strengthen existing organisations to deal with problems and assure implementation of decisions of inter-State nature like those of the Yamuna River, Goverdhan Drain etc.

(viii) It is seen that about 6.4 lakh hectares in the upper catchments of the rivers are subject to soil erosion. Only about 0.56 lakh hectares have been treated so far, thus leaving about 5.84 lakh hectares yet to be attended to. According to the plan 1978—83, the target for treatment of the hill catchments is 28,500 hectares. At this rate it will take almost 100 years to treat the balance of 5.84 lakh hectares. Even with an accelerated programme, it may still be 60 to 70 years before the watersheds can be fully treated. This is too long a period. It is, therefore, recommended that steps should be taken to expedite treatment of the watersheds of the flood-prone rivers on a priority basis.

This would still leave areas in Nepal which could be dealt with only after negotiations with the Nepal Government are completed. Attempts should be made to come to some agreement in this regard for an early start in the treatment of watersheds in that country.

14.28.6 *Bihar*

The problem

For consideration of the flood problem, the State may be divided into three zones viz. North Bihar plains, South Bihar plains and Chotanagpur and Kaimur plateau.

The North Bihar plains are mainly flat except the small area of Someshwar hills, the north-west corner of this zone. The area is drained by the rivers Ghaghra, Gandak, Burhi Gandak, Bagmati, Adhwara Group of rivers, Kamla, Kosi and Mahananda. This is the most flood prone zone in the State. The larger rivers originating from the Himalayas in Nepal, carry enormous silt-laden discharge during the monsoon and after traversing the steep foothills start spilling as they debouch into the plains of North Bihar. The problem becomes still more acute in their outfall reaches when floods in these rivers synchronise with those in the Ganga. The tributaries of these larger rivers also cause flooding which becomes acute when tributary floods synchronise with those of the main rivers. Some of the North Bihar rivers have past history of frequently changing their course and having lateral shifts, creating new problems of floods and sand casting over extensive areas. The flood problem in the zone of North Bihar comprises inundation of areas due to spilling over the banks, surface drainage congestion and threat of erosion of townships and villages. The frequency and extent of the problem is high.

The South Bihar plain is bounded by the river Ganga in the north and Chotanagpur, Santhal Parganas and Kaimur plateau in the south. The important rivers traversing are the Karmnasa, the Sone, the Punpun, the Kiul, the Badua, the Chandan and the Gumani. The Sone originates in the Vindhyas in Madhya Pradesh and the Karmnasa in the Kaimur plateau in the State of Uttar Pradesh. The rest of the rivers originate in Bihar, from the hills of Chotanagpur, the Santhal Parganas and the Kaimur Range. These rivers are flashy with inadequate sections to cope with the flood peaks and are mostly dry in the non-monsoon months. There is flood lockage at the outfall reaches of all these rivers when the Ganga is in spate. The flood problems are mainly inundation of the countryside, threat of erosion of townships and villages, and surface drainage congestion in the low lands in the northern part near Ganga.

The Chotanagpur Santhal Parganas and Kaimur plateau zone is characterised by series of low hills and valleys and depressions filled by alluvial detritus. The major rivers in the zone are the Subernarekha, North Koel, South Koel, Ajay, Damodar, Konar and Barakar. Mostly non-perennial, these rivers drain the rocky terrain typical of area. These rivers do not generally cause flooding in the zone, although they cause flooding in the neighbouring States of West Bengal and Orissa. However, during exceptional floods some spills occur in the lower reaches of the larger rivers. The flood problem mainly comprises erosion of towns and villages and occasional spillage causing disruption of road and railway traffic.

The problem, mainly in North Bihar and to a smaller extent in South Bihar may, therefore, be stated as:

(i) spillage which causes extensive damage.

(ii) silting and tendency of some rivers to breaches and avulsions.

(iii) floods in the Ganga causing lockage in the tributaries.

(iv) drainage congestion in depressions and flat areas.

Previous Committee/Experts

Appointed by the State

A number of Committees were appointed by the State Government. The Kosi Technical Committee appointed in 1965 recommended construction of a second barrage on the river, training works, dredging and bandalling, conservancy measures to stabilise the channel and increase the hydraulic efficiency of the river. They also recommended flood warning system, demarcation of flood hazard zones and comprehensive soil conservation measures.

The High Level Committee on Patna Floods constituted in 1975 recommended the construction of embankments/masonry walls and revetments along the south bank of the Ganga, construction of a new embankment along the right bank of the Sone, raising and strengthening of the left embankment of the Punpun and improvement in the drainage system in town and rural areas.

Appointed by the Centre

The Committee on Flood Control in Adhwara Group of rivers appointed in 1964 recommended channelisation of the river Darbhanga-Bagmati, diversion of a part of the discharge of the Bagmati into the old course of the river Kamla, provision of embankment in reaches where the river spills and adequate number of sluices.

The North Bihar Drainage Committee set up in 1965 recommended provision of adequate drainage systems in irrigated areas and additional waterways for road and railway bridges.

The Gandak High Level Committee set up in 1971 recommended strengthening of the embankments, implementation of additional works downstream of the Balmiki Nagar barrage, investigation of multipurpose reservoirs in the upper catchment of the Gandak, channelisation of the river and adequate maintenance.

The Subarnarekha Committee constituted in 1972 recommended provision for flood storage in the proposed reservoir at Chandil, construction of embankments in West Bengal and Orissa and improvement of drainage in the lower basin and channelising the river towards its outfall into the sea.

The Working Group on Integrated Action Plan for Flood Control (in Indo-Gangetic basins) 1978, suggested storage on the Subarnarekha and Ajay rivers and flood cushion in the reservoirs proposed on the tributary of Burhi Gandak and tributaries of the Sone like North Koel. The Group also recommended investigations and finalisation of schemes on the tributaries rising in Nepal. Recommendations have also been made for soil conservation, aforestation and watershed management.

Measures taken so far

A large number of embankments, mainly in North Bihar, have been constructed before and after the Policy Statement in 1954. The century old embankments along the Gandak which have stood the test of time are worth mentioning. Other important embankments are those from the Indo-Nepal border along the Bagmati, the Kamla and the Kosi. Embankments have also been constructed in stretches along the left bank of the Gandak. In South Bihar, important embankments are on the left bank of the Punpun, right bank of the Sone and for some length along the right bank of the Ganga for protection of Patna town.

Town protection schemes have been executed for saving important towns like Chapra, Khagaria and Darbhanga.

River improvement schemes have been undertaken for some rivers in North Bihar.

Flood control storages have been constructed in the Damodar Valley. Soil conservation measures have been taken by the DVC in the Damodar basin in Chotanagpur Plateau. So far no flood detention reservoirs, village raising or soil conservation works have been undertaken for benefiting Bihar areas.

Five-Year Plan 1978—83

The State has proposed construction of new embankments, raising and strengthening of the existing embankments, town protection, anti-erosion and channel improvement schemes.

The Working Group for the Plan has, however, suggested that future embankments should be taken up with caution after studying their effects on the river regime.

Future programme envisaged by the State

The State had prepared a so-called master plan for flood control with a total outlay of about Rs. 480 crores for providing protection to about 14.80 lakh ha. This master plan was mainly list of works, without investigations or considering the overall picture. Later, the State submitted to the Working Group on Integrated Action, 1978, a 5 to 7 years' action programme costing over Rs. 870 crores for benefiting an area of 28.33 lakh ha.

The problems dealt with by the State programmes are mainly those of spilling and congestion in the basins of the Ghaghra, the Gandak, the Burhi Gandak, the Bagmati-Adhwara, the Kamla, the Kosi and the Mahananda in North Bihar and the Sone-Ganga-Karmanasa-Punpun and the Harohar-Kiul basins in South Bihar and of erosion in most of them.

The Programme recognises the necessity of measures like flood detention reservoirs and watershed management in the upper catchments. The North Bihar rivers originate in Nepal, where dams on the Bagmati, the Kamla, the Kosi and the Mahananda have been visualised, a dam on the Burhi Gandak' has been planned within the State territory. In view, however, of the fact that negotiations with Nepal will take some time, the works currently visualised in North Bihar are mainly raising and strengthening of embankments, anti-erosion measures, removal of drainage congestion and raising of villages as far as possible.

In the South Bihar plains, the areas to the north of the river basins of the Sone-Ganga-Karmanasa-Punpun and the Harohar-Kiul are proposed to be protected from the recurring Ganga floods by construction of embankments in specific reach of the Ganga and backwater embankments along the major tributaries. Anti-erosion works for protection of habitations, important lines of communications and removal of surface congestion have also been visualised.

Suggestions

(i) The programme for the Action Plan as framed by the State is likely to take a long time for implementation. It is suggested that priorities may be fixed and basinwise plans detailed after considering the various alternatives.

(ii) Wherever storages are proposed within the State itself, flood cushion should be provided if required.

(iii) As suitable storage sites on most of the North Bihar rivers lie in Nepal, efforts should be made for joint and coordinated projects for water resources development and watershed management in these basins.

While keeping in view the possibilities of these reservoirs, other measures like embankments etc., should be considered and master plans prepared and executed basinwise.

(iv) Watershed management and soil conservation measures within the State should receive high priority.

(v) Anti-erosion works are expensive in capital and maintenance costs and should be avoided, except for protecting important installations and large habitations. Alternative measures like shifting of villages should be considered where possible.

(vi) Not only for financial but even for technical reasons it may not be possible to provide protection to some of the flood-prone areas of the State. The strategy of "living with the floods" described in Chapter V would be apt in such areas.

(vii) Surveys and investigations should be given high priority to enable proper preparation of schemes.

14.28.7. *West Bengal*

The problem

For consideration of the flood problem, West Bengal may be divided into three zones, *viz.*, (i) North Bengal, (ii) Central Bengal and (iii) Southern Bengal.

Only the Mahananda river system of the Ganga basin falls in North Bengal. Coming down a steep slope in the hill region, the Mahananda brings down a heavy silt load during the monsoon. It starts spilling as it debouches into the plains of North Bengal. Silting of the river channel results in changes of the river course, spilling and bank erosion at places.

The Central Bengal region is traversed by rivers of the Ganga-Bhagirathi system, namely, the lower Mahananda, the Bhairab, the Ajay, the Mayurakashi etc. In the area north of the Ganga, the Mahananda and its tributaries and spill channels cause inundation and silt deposit. The problem becomes more acute when there is synchronisation of floods in the Ganga and the Mahananda. In the area south of the Ganga, the previously active channels like the Bhairab, which used to receive flood spills of the Ganga before it avulsed into the Padma, and the original course of the Ganga known as the Bhagirathi after the avulsion, are getting silted up due to inadequate headwater supplies. Newer channels like the Jalangi, the Mathabhanga and the Churni are also deteriorating. The river Bhagirathi is now unable to carry the discharge of Ajay. Some of the areas are also subject to flooding and waterlogging as they are at comparitively lower levels. The Bank erosion of the Ganga and the eastern branch of the Mahananda also pose problems.

The problems in the Central Bengal may, therefore, be said to be mainly over-bank spills in the Mahananda and the Ganga, surface drainage inadequacy causing spilling and drainage congestion and bank erosion.

The Southern Bengal region can be divided into three separate zones as under, according to individual problems.

(a) Southern portions of Hooghly and Howrah Districts and Eastern portion of Midnapore District.

(i) Drainage is the main problem, the reasons being: deterioration of main rivers like the Saraswati, Damodar, Kana-Damodar, Kana Nadi, Rupnarayan, Dwarkeshwar, Silabati, Kangsabati, Kaliaghye, Resulpur etc.,

(ii) inadequate capacity of the excavated drainage channels which have been initially designed with a lower drainage index,

(iii) inadequate provision of drainage sluices,

(iv) encroachments/obstructions in the river sections,

(v) construction of embankments almost along the river edge thereby cutting off the spill zones,

(vi) levels of drainage channels being higher than ground levels in some areas,

(vii) lockage of inland drainage by sea tides, worse during synchronisation of heavy precipitation with spring tides,

(viii) cyclonic storms and coastal erosion,

(ix) inadequate sections of existing zamindari embankments, and

(x) heavy silt deposits in rivers like the Kangsabati, Silabati, Dwarakeshwar etc., due to denudation of their catchment areas.

(b) Trans-Damodar Area

Trans-Damodar area consists of catchment areas of the Damodar and the Mundeswari (Rupnarayan) river systems. Silting of and encroachments into the river zone has resulted in deterioration of their carrying capacity, so much so, that even the moderated floods from the DVC dams cause extensive flood damage. The areas being low, once they are flooded during the rainy season, drainage congestion persists for long periods.

सत्यमेव जयते

(c) 24-Parganas including the Sunderbans

The problem of this area is drainage congestion created by various factors, the principal being:—

- (i) Premature reclamation of land thus preventing full process of delta formation,
- (ii) cutting off of the Ganga supply into the Bhagirathi during the major portion of the year, causing deterioration of the entire Bhagirathi river system and the connected drainage channels,
- (iii) tidal effect and locking of drainage for a considerable period during high tide,
- (iv) difficulty of gravity drainage into rivers becoming silted due to gradual deterioration and insufficiency of drainage sluices in the embankment,
- (v) cyclonic storms and coastal erosion, and
- (vi) frequent breaches in ex-zamindari embankments.

The main problem, therefore, is acute drainage congestion.

Previous committees/experts

The important recommendations of the High Level Committee on Floods, 1957, were to improve the drainage systems, remove inadequacy of waterways in bridges, and channel improvements etc.

The Ministers' Committee on Flood Control, 1964, recommended flood detention reservoirs, marginal embankments, town protection schemes, extension of waterways under the bridges, river improvement and anti-erosion works, survey and investigations, flood forecasting, drainage improvement and anti-waterlogging schemes.

The Technical Experts Committee on Floods in North Bengal, 1968, recommended soil conservation in upper catchments, extension of waterways under road and rail bridges, embankments and river training works.

The Committee on Flood Control and drainage in Lower Damodar, 1971, recommended acquisition of land at Maithon and Panchet reservoirs for providing full design flood storage capacity embankments along Damodar and Mundeswari rivers, dredging of Rupnarayan river, modifying the schedule for reservoir operation and improvement in the flood forecasting system.

The Subarnarekha Committee, 1972, recommended flood storage in the proposed reservoir at Chandil in Bihar, embankments in West Bengal and Orissa and providing straight cuts to the sea.

The Working Group on Integrated Action Plan, 1978, recommended, amongst others, reservoirs on the Ajay and the Sidheshwari, embankments and drainage schemes.

By the State

The West Bengal Inquiry Committee set up in December, 1959, recommended that the question of retention or otherwise of some of the ex-zamindari embankments should be examined and embankments along the river channels in lower Bengal should, as a matter of principle, be discouraged. For improving the deteriorating river channels and disposing the runoff from the upper catchment and precipitation from the locality speedily and efficiently, re-sectioning of some of the channels, remodelling structures on or along them and silt clearance by dredging and river training works were recommended. The other recommendations were intense data collection programme including aerial surveys, investigation of schemes necessary for flood prone areas, and, raising of villages.

Measures taken so far

Of the important works undertaken and completed in North Bengal so far, mention may be made of Siliguri Town Protection Work on the left bank of Mahananda and Diversion of the river Karala, and construction of embankments along the Mahananda river.

In Central Bengal quite a number of flood protection and drainage schemes have been executed. Mention may be made of the Sambalpur embankment on the river Mahananda, Malior embankment on river Phulhar and Mahananda-Ajay left embankment (1st phase), Ajay right embankment (1st phase), etc. Buriomondal Drainage Scheme and anti-erosion works on the Ganga may also be mentioned.

The Bagjola-Ghuni-Jatragachi scheme, Contai basin drainage scheme, Keora-Pukur basin drainage scheme, construction of drainage sluices in Sunderbans, improvement of drainage sluices of areas within Damtbhanga Beel, Mainkhalo basin drainage scheme, Sonarpur-Arabpanch Melta basin drainage scheme etc., are the more important schemes among those completed so far in the South Bengal region.

A number of other embankments, town protection works and drainage schemes have also been completed.

A series of multipurpose dams have been constructed on the Damodar system with flood control as one of the main objectives.

Five Year Plan 1978—83

The proposals framed by the State Government comprised 174 Nos. continuing and 229 Nos. new projects, for which outlays of Rs. 78.74 and 159.11 crores respectively were proposed. These schemes, on execution, envisaged benefits to an area of about 6.09 lakh ha.

Observing that some of the schemes had been continuing since 1970-71, the Sub-Group, which examined the proposals, stressed the necessity of completing all the on-going schemes during the Plan period. The Group further observed that the State Government's proposal to take up as many as 229 new schemes estimated to cost about Rs. 755 crores amounts to thin spreading of available resources. It was, therefore, decided that the State would review in detail their proposals of new schemes and include only such which could be substantially completed during the Plan with some spill-over into the next Plan.

The Sub-Group recommended an outlay of Rs. 190 crores for the Plan as detailed below:—

(i) Completion of all on-going schemes.	Rs. 80 crores
(ii) New schemes to be substantially completed during the Plan period.	Rs. 107 crores.
(iii) Water development services—including collection of data, surveys and investigations, preparation of master plans, monitoring etc.	Rs. 3 crores
TOTAL .	Rs. 190 crores.

Future programme envisaged by the State

In their reply, the State Government have indicated schemes of Rs. 437 crores for anti-erosion (including Rs. 37.50 crores for anti-sea erosion works) and schemes for drainage and flood protection amounting to Rs. 229 crores for North Bengal, Rs. 94 crores for Central Bengal and Rs. 416 crores for Southern Bengal.

सत्यमेव जयते

Anti-erosion works have been proposed on almost all the rivers, the largest amounts being Rs. 288 crores for the Ganga, Rs. 37.5 crores for the Hooghly and Rs. 21.25 crores for the Bhagirathi. The Basirhat and Taki town protection schemes in the Ichhamati basin have been included as priority schemes.

Amongst the drainage schemes, the State has given priority to the following:—

(i) Burhi-Shyam-Sunderpur beel drainage scheme and Kendua basin drainage scheme (Phase I, II) in Damodar basin.

(ii) Moina basin drainage scheme; re-excavation of Chandrashekhar Khal; resectioning of Panchthupi and Chandia rivers in Kangsabati basin.

(iii) an integrated flood control and drainage scheme for river Mayurakshi, Bable and Dwarka to tackle the problem of floods of Kandi areas in Mayurakshi basin.

(iv) Ghatal and Tamluk master plans (both in Midnapore district); Kherai Boxi drainage scheme; re-sectioning of Bhosra Khal, Cossye and Barbachati rivers and Patchonda-Panchthupi Khals in Rupnarayan basin.

(v) resectioning of Kaliaghye river and Dubda basin drainage scheme in Kaliagnye basin.

(vi) excavation of river Ichhamati at Bongaon as well as river Churni at Ranaghat in Ichhamati basin.

(vii) Ghea-Kunti drainage scheme in Khari-Gangur-Ghea basin.

(viii) urgent development of Sunderbans area.

(ix) resectioning of rivers Sealmari and Jalangi in Jalangi basin.

In addition to these, a few drainage schemes in the Sunderbans basin, namely, Sonarpur-Arapanch, Matla drainage scheme, East-Mograhat basin drainage scheme, West Mograhat basin drainage scheme, Nowi basin drainage scheme, Sealdahgang basin drainage scheme, Bheel-Balli drainage scheme and improvement of Sunti river have also been proposed by the State Government.

Important schemes for flood storage proposed by the State are on the rivers Ajay, Bansloi and Pagla. A dam has also been proposed on the Kangsabati. The State Government has also indicated priority for land acquisition in Maithan and Panchet dam reservoirs for getting the full benefit of flood moderation in Damodar system.

Amongst the embankment schemes, the State Government attaches priority to the following:—

(i) the on-going 80 km long embankment scheme along the Mahananda in Malda district,

(ii) a new scheme for construction of embankment on the left bank of the Mahananda (Barsoi Branch),

(iii) Kunur river embankment scheme in Ajay basin,

(iv) scheme for improvement of Lower Damodar area in three stages.

Suggestions

(i) A provision of Rs. 3 crores has been made in the Five Year Plan 1978—83 for collection of data, surveys and investigations, preparation of master plans etc. Collection of data is a continuous process and the present provision will not fully meet the needs. Such a provision would need to be made in the future Plans also.

(ii) There are a number of on-going schemes and it is essential that they should be completed as fast as possible and in any case during the Plan 1978—83.

(iii) The problem in the State to a great extent, is that of drainage in West and South Bengal. A number of schemes have been proposed by the State. As all of them cannot be taken up concurrently, only some important ones may be undertaken during the five-year period.

The project "Urgent development works in the Sunderbans area" appears to be important and may be undertaken as a priority.

(iv) There is not much scope of storage reservoirs in the State. Proposals have, however, been made for storage dams on the Ajay, Bansloi and Pagla rivers which are likely to have scope for provision of flood space. Investigations of these schemes should be expedited.

(v) Now that a decision has been taken for raising the water levels in the Maithon and Panchet reservoirs for achieving the full benefit of flood cushion in the DVC system, the necessary land acquisition should be completed as early as possible.

(vi) The State Government has received a report from the Committee constituted by them for examining the Lower Damodar scheme. A decision on the recommendations of the Committee may be taken at an early date and steps initiated towards implementation so as to mitigate, if not obviate, the recurring flood damages caused by out-flows from the DVC reservoirs.

Embankments are not unmitigated blessings in flat terrains like that of Central and South Bengal they also lead to problems of drainage congestion. Adoption of embankments in future in any great measure may, therefore, be undertaken only after a citical study of the local conditions of the area and the river.

(vii) The State has under consideration the construction of a number of anti-erosion works on both banks of the Ganga and in the vicinity of Warakka barrage Anti-erosion works are expensive and should be undertaken only after ensuring economic viability and technical feasibility.

(viii) As the rivers flow through flat terrain sediment loads cause aggradation and affect river regime, besides reducing life of storages. Watershed management, soil conservation and afforestation measures should, therefore, receive high priority in Plan programmes of the State.

THE NORTH-WESTERN RIVERS BASIN

14.29. The North-western Rivers Basin

This region comprises parts of the Indus river and its five tributaries, namely, the Jhelum, the Chenab, the Ravi, the Beas and the Sutlej. The region covers the States of Jammu and Kashmir and Punjab, and, parts of Himachal Pradesh, Haryana and Rajasthan; parts of Himachal Pradesh and Haryana fall in the Ganga Basin and those of Rajasthan in the Ganga and the Central India and Deccan Rivers Basins. Since substantial areas of Haryana and Rajasthan are also covered by Ganga basin, these States have been dealt with under that Basin.

The main flood problem experienced in Jammu and Kashmir is caused by the river Jhelum. The Ghaggar which used to disappear in the sandy dunes, has now become active partly in the Punjab and mainly in Haryana. The main problem in this region is drainage, which is mixed up with extensive irrigation.

The choes (hill torrents) in the Punjab bring a lot of sediment and sand and damage irrigation fields; integrated development of their basins are under implementation.

Dams have already been constructed on the Sutlej and the Beas rivers; the one on the Ravi is expected to start shortly. A dam on the Jhelum system may be helpful in the flood problem around Srinagar and Wullar Lake.

14.29.1 *Jammu and Kashmir*

The Problem

The State can be divided into three regions, namely, the Kashmir Valley, Jammu Province and Ladakh area. The Valley is the most flood prone area; the problems in Jammu Province are mainly of overspilling and bank erosion; Ladakh is practically free from floods except on very rare occasions (like 1978) when areas may be inundated due to a cloud burst.

The floods in the Valley are caused by the river Jhelum and to some extent by its tributaries. For dealing with the problem, the river has been divided into three reaches, namely (i) upstream of Srinagar, where owing to the channel capacity being insufficient to carry the high flood discharge estimated at 90,000 cusecs (2549 cumecs) at Sangam, there is overbank spill and overtopping of/breaches in the embankments, (ii) through Srinagar where the capacity of the river channel is inadequate to take the flood flows and (iii) at Wullar Lake where owing to insufficient capacity of the outfall channel to quickly drain off the flood waters reaching the Lake, there is heading up and flooding of land at the margins of the Lake and upto Srinagar. The problem is aggravated on account of the silt brought down by the Pohru river emptying into the outfall channel and causing blockages.

In Jammu Province, the problem is caused mainly by the Chenab, the Ravi and their tributary nallas and comprises erosion of banks and over-spilling at various locations.

Previous Committees/Experts

Appointed by the State

The problem of the Valley has received attention from early part of the century. Starting with a report by R. E. Purves in 1915, the problem has been dealt with by Tulsi Dass after the floods in 1928 and by D. G. Harris in 1929 by way of advice on Tulsi Dass's proposal.

After the severe floods of 1950, Dr. H. L. Uppal, Director of Irrigation and Power Research Institute, Punjab, studied the problem. His main recommendations are realignment of bunds in certain reaches below Dongripura, strengthening of bunds between Sangam and Dongripura, effecting two cut-offs in the river upstream of Srinagar, constructing a supplementary channel from Dongripura to Wullar making use of depressions and the existing flood spill channel, diversion of the Pohru river into Wullar Lake and improvements to the outfall Channel below the Lake. In 1953, these proposals were examined by a Board of Engineers, who agreed with most of Dr. Uppal's proposals.

During 1953 and 1954, the problem was examined by the then Central Water and Power Commission. Amongst others they recommended enlarging the spill channel, construction of a supplementary channel and some improvements to the outfall channel below Wullar Lake.

In order to evaluate the works executed so far and reapprise future proposals, a High Level Flood Committee was set up in 1975. Their report, submitted in 1976, has been accepted by the State Flood Control Board. Their main recommendations comprise improvement to flood spill channel, use of detention basins upstream of Srinagar (to be finally replaced by a supplementary channel), improvements to the outfall channel, strengthening of embankments, surveys and hydrological observations etc., in the case of the Valley and channelising and spot anti-erosion works for rivers and nallas in the Jammu Province.

Appointed by the Centre

The High Level Committee (1957) suggested consideration of the alternatives of constructing a supplementary channel or making use of depressions as detention basins upstream of Srinagar, improving and increasing the capacity of the flood spill channel by-passing Srinagar, improvement of the capacity of the outfall channel below Wullar Lake, construction of a spill channel by-passing the Lake and diversion of the Pohru into the Lake.

The Ministers' Committee on Floods (1964) recommended that the tempo of work on the outfall channel be increased, schemes of soil conservation and detention basins on the Pohru be pursued more vigorously and flood control works in the Jammu Province be accelerated.

Measures taken so far

Kashmir Valley

Some time in the past, a length of the river below Sangam was embanked on both sides, and above Sangam in scattered reaches. Some of the tributaries of the Jhelum were also embanked in their lower reaches. All these embankments were of insufficient section.

Flood spill channel, with a capacity of 17,500 cusecs (496 cumecs), by-passing Srinagar town was constructed in 1904. Since silted up to a reduced capacity, it is being rehabilitated.

A number of remedial measures have been in progress, the important ones being:—

(i) Raising and strengthening of embankments both upstream and down stream of Srinagar.

(ii) Improvement of the river channel through the city and the city channels.

(iii) Improvements and extension of the Flood Spill Channel to its original capacity of 17,500 cusecs (496 cumecs) by-passing Srinagar town.

(iv) Improving the outfall channel from a capacity of 17,000 cusecs (481 cumecs) to 35,000 cusecs (991 cumecs) downstream of Wullar and to a capacity of 40,000 cusecs (1133 cumecs) against the present one of 19,000 cusecs (538 cumecs) at Khadanyar; as also ancillary works like widening of bridges, deepening and widening of narrow gorges, stabilising of the hill torrents falling into the outfall channel etc.

(v) Soil conservation measures in the catchments of Pohru and other streams which bring in large quantities of silt.

(vi) Spot treatment works on tributaries.

(vii) Survey and hydrological observations.

The total outlay upto March 1978 is about Rs. 17.67 crores. This excludes cost of soil conservation measures which falls within the purview of the Forest Department.

Jammu Province

The problem is bank erosion change of nalla courses and overspill from rivers, mainly the Ravi and the Chenab and the various nallas in the region. The flood protection measures undertaken comprise river training and anti-erosion works on the rivers and nallas. The expenditure upto March 1978 is about Rs. 4 crores.

Five-Year Plan 1978—83

The High Level Flood Committee, 1975 mentioned earlier has reappraised the problem and their recommendations have been accepted by the State Flood Control Board. For the Kashmir Valley, the following works have been recommended as Phase-I to be undertaken during 1978—83:—

(i) Improvement of Flood Spill Channel.

(ii) Detention basins above Srinagar.

(iii) Improvement of the river through the city and of the city channels.

(iv) Outfall Channel improvements including procurement of a dredger unit.

(v) Surveys, hydrological observations and studies.

(vi) Spot treatment and training works.

Practically, all these are continuing schemes. Stress has, however, been laid on their completion in 10 to 12 years; the cost is estimated at Rs. 60 crores. The proposals are under examination with the CWC.

The measures to be undertaken in the Jammu Province are channelisation, river training and anti-erosion works. An outline master plan has been prepared but it has yet to be submitted to the State Flood Control Board and the Central Water Commission.

Future programme envisaged by the State

सत्यमेव जयते

The works mentioned above will need more than five years to complete and will, therefore, continue beyond the present Plan.

Since the capacity of the river through Srinagar is not enough to take total flow coming down from Sangam, the ultimate solution visualised by the Committee is a supplementary channel from Sangam to Wullar Lake. The detention basins have been proposed as an intermediary stage. It is, however, understood that the State is reviewing the proposal and considering the adoption straightaway of the alternative of the supplementary channel from Sangam to the Flood Spill Channel.

The State Government proposes to, for the present, improve the Outfall Channel to a capacity of 35,000 cusecs (991 cumecs) only and to restrict the works corresponding to that capacity.

It is proposed to raise, strengthen and widen the embankments from Sangam to Srinagar. Downstream of Srinagar also, embankments are proposed to be raised and strengthened. Also spillways are proposed to be provided in the embankment for silting up areas on the right bank.

In Jammu Province, spot treatment measures like embankments, anti-erosion works and river training will continue. A Master Plan is being formulated.

Suggestions

In the nature of things, an appropriate approach to the flood problem in the Valley, would consist of measures to contain the river flows within embankments, controlled flooding of depressions to act as detention basins till such time as they silt up and yield reclaimed land, restricting flows through Srinagar to safe capacitpy, controlling the level in the Wullar Lake, and watershed management. A dam on the Jhelum system if found feasible at a location upstream of Srinagar, would go a long way in easing the flood problems of the Valley.

Anti-erosion works, embankments and river training works should be planned and executed as necessary.

The following suggestions may supplement the future programme visualised by the State:

(i) The present measures provide for a flow of 90,000 cusecs (2549 cumecs) at Sangam; this is stated to be a flood, of 10 years' frequency. Final planning should be for a 25 years' flood for embankments upstream of Srinagar; breaches, overtopping of banks and use of depressions as detention basins should be visualised in case of higher flows.

Protection of Srinagar town should be planned for a flood frequency of at least 100 years, or for the observed flood, if higher; in due course, the protection should be reviewed in the light of additional data available and raised if found necessary. The flood Spill Channel and the Supplementary Channel would need to be ultimately designed accordingly.

(ii) The supplementary channel, if constructed now, would have to negotiate a number of depressions; this will make its maintenance difficult and expensive. As such, and as already proposed, use may be made of the detention basins for the time being. The supplementary channel could be considered after the detention basins have silted up, thus making it easier to properly align, grade and maintain this channel.

(iii) The capacity of the outfall channel should finally be enlarged to the extent required to ensure that the design H.F.L. of the Wullar Lake is not exceeded for the design flood inflow.

(iv) The Valley has numerous depressions/lakes. The possibility of using these as detention basins on the tributaries may be explored.

(v) The progress on soil conservation measures is very slow. It is also noticed that the subject is dealt with by the Forest Department in isolation. As Engineering and Agricultural Departments are intimately concerned with the matter, the programming and execution should be undertaken in a joint manner. Priorities should be laid down and adequate funds provided for time-bound programmes.

(vi) The tendency of rivers and nallas in the Jammu Province to shift courses may reduce if their channels could be contained. As an experimental measure, a selected reach of a stream may be jacketted; if successful, this may prove an economical solution in a number of locations.

(vii) Surveys and hydrological observations and studies are items of continuing nature and should not be allowed to languish.

(viii) The formulation of the Master Plan for the Jammu Province should be expedited.

70.29.2 *Punjab*

The problem

The Punjab forms part of the Indus basin. Three principal tributaries, viz., The Ravi, the Beas and the Sutlej traverse the State; they all originate in the Himalayas.

The river Ghaggar rises in the Sivalik hills and after traversing through the Punjab and Haryana in a southwesterly direction disappears in the sand dunes of Rajasthan.

In addition, there are a number of choes (hill torrents) flowing down steep hill slopes and bringing heavy sediment loads, they clog channels, change courses and damage land.

Dams have been constructed on the rivers Beas and Sutlej, a dam is proposed on the Ravi. The flood problems of the Beas and the Sutlej downstream of the dams have, therefore, been largely mitigated. Some flood damage is caused by the Ghaggar and the choes, both of which are flashy in nature.

The main problems in the State, however, is drainage. Being an intensively irrigated area, the land is subject to waterlogging; also being flat, rain water does not quickly drain off.

The Himalayas are sedimentary rocks with loose soil mantle. Underpressure of population and development, the hills continue to be denuded and, therefore, soil erosion is extensive. Eroded soils choke the rivers and block drainage.

The main problem in the State, may, therefore, be stated to be:—

(i) spills over river banks.

(ii) inadequate waterways across roads, railways and irrigation channels etc.

(iii) inadequate drainage.

(iv) denudation of catchment areas.

(v) damage by the choes.

Previous Committees/Experts

Several Committees have examined the flood and drainage problems of the State. The more important ones are the Flood Control Committee, 1975 and the Sutlej Embankment Technical Committee, 1978, both set up by the State Government.

The 1975 Committee recommended measures for effective protection of embankments along the Ravi till such time as the floods are moderated by the storage dam at Thein. They recommended:—

(i) reconditioning and strengthening of flood embankments on both banks.

(ii) anti-erosion works like spurs at vulnorable points.

(iii) inlets at suitable points through the embankments for drainage of protected areas.

With regard to the Beas, the Committee stated that additional strengthening and river training measures only would be required for he existing embankments. In respect of Sutlej, the Committee recommended completion of gaps left at certain reaches of the embankment, strengthening of the embankment and closure of inundation canals.

The 1978 Technical Committee stated that embankments be designed for 25-year frequency flood; it also suggested construction of embankments along tributaries to cater for the backwater heading up at confluences, and, taking up of localised anti-erosion/river training works at places where the embankments are already threatened or likely to be threatened.

The Board appointed by the Government for the development of sub-mountainous areas affected by choes, has recommended treatment on an integrated basis. They have further recommended early completion of work on hand and extension of the treatment to other areas.

Measures taken so far

Flood embankments have been constructed along all the rivers, even on some of the tributaries. Anti-erosion works like spurs etc., also have been constructed at vulnerable points. The embankments along the Sutlej are a special feature as they are designed to jacket the river down-stream of the Bhakra. It was expected that due to flood moderation at the dam, the chances of flooding in the river would be obviated. Flood damages have, however, occurred in one or two years since the dam was constructed, mainly due to encroachments in the river plains.

An integrated programme has been started in the hill areas to control the choes.

A very large number of drainage schemes have been constructed in the State. A large number of these drainage shemes are in irrigated areas, where a combination of factors like waterlogging flat country slope and heavy precipitation result in drainage congestion.

Five Year Plan 1978—83

The Five Year Plan document of the State does not contain details of the various proposals. The present master plan visualises an outlay of Rs. 145 crores providing for 11,270 km of surface drains and 1,160 km of flood protection embankments. Out of these 5,450 km of drains and 790 km of embankments have been constructed till March 1977. The remaining work has yet to be done. During the Plan it is proposed to complete 395 km of embankments and 941 km of surface drains.

The provision made is about Rs. 49 crores. It is also stated that this amount, not being adequate, will have to be supplemented by the Central Food for Work Programme.

Future programme envisaged by the State

Excavation of new drains, widening and deepening of existing drains, construction of village road bridges and construction of new flood protection embankments are to be continued.

According to the State's Plan, "The short-term solution lies in an effective drainage system", and "Water is too precious an asset just to be drained out. The real long-term solution lies in impounding it for meeting the growing requirements of modern agriculture industry and daily life." The State visualises an integrated programme for efficient and judicious utilisation of surface and ground waters.

Suggestions

(i) It is noticed that construction period for schemes, specially drainage schemes, is rather long during this period the annual maintenance charges are quite often, being debited to "Capital" account. This is not a correct practice Delays are stated to occur due to land acquisition and to the practice according to which drains are constructed as soon as possible and time is taken on construction of cross drainage works. It would be realised that long construction periods entail amounting establishment interest and depreciation charges, which unduly raise the cost of the project, and, reduce the actual benefit-cost ratio. It is, therefore, suggested that once started, schemes should be completed in all respects within the shortest possible time

If land acquisition or masonry works are to take longer, it should be possible to prepare separate estimates for the same.

It is also recommended that once a functioning element of any scheme is physically complete maintenance should not be charged to "Capital"

(ii) The drainage network of the State is the largest in the country. It is, however, understood that for lack of adequate and timely maintenance, the drains get silted and desilting becomes necessary. It is also stated that it is not possible to resection the drains from the annual maintenance funds. It is necessary that funds should be found from "special repairs" or otherwise, to bring the drains to proper sections.

(iii) The present integrated programme initiated in the areas drained by the choes, should be carried out with all possible speed and extended to cover other affected areas also.

(iv) The Bhakra and the Pong reservoirs constructed on the Sutlej and the Beas do not have any reserved flood space. It is recommended that the usefulness of providing some flood cushion in the proposed Thein storage should be carefully examined and the cushion provided as necessary.

(v) Land regulation in the protected areas and prevention of encroachments in the flood plains are necessary measures for mitigation of flood losses; these should be implemented.

(vi) In order to keep the river channel clear of encroachments, obstructions and in proper functioning condition, flushing doses of upto the designed spillway discharge should be let down from the reservoir as often as possible.

(vii) Watershed management, afforestation and soil conservation measures are of extreme importance. Most of the catchments, however, lie in the adjoining State of Himachal Pradesh. It is recommended that the two States should get together, plan and implement schemes so as to reduce the sediment loads in the rivers. In this connection the Bhakra Soil Conservation Board, which appears to have become dormant, may be activised/revived as necessary.

4.29.3. *Himachal Pradesh*

Most of the State is drained by the four tributaries of the Indus viz., the Chenab, the Ravi, the eas and the Sutlej; a small area drains into the anga basin through its tributary, the Yamuna.

There are no major flood problems in the tate, except fast flowing rivers and seasonal Khads" which cause erosion of land and pose anger to scattered habitations along the rivers nd the streams. Large scale deforestation esults in reduction of land productivity, soil rosion and silting of rivers and reservoirs.

Measures taken so far

The State has undertaken the work of surveys nd investigations of flood control schemes from he year 1966, but the implementation of the chemes has only been taken up recently in low ying areas and parts of Kangra and Mandi istricts.

Work of soil conservation in the State was active under a High Power Soil Conservation Board in which the Bhakra Management was a partner. The Board is understood to have been wound up since.

Upto March 1978, 15 km of embankments, 13 km of drainage channels and 3 town protection works have been completed, protecting an area of 4,000 ha. In addition, 11 numbers of villages have been raised.

Suggestions

There is no significant problem requiring major attention in the State. The problem is localised in nature, requiring local action. The following general suggestions may, however, be kept in mind:—

(i) Check-dams would minimise tendency of erosion by hill streams, and may be taken up as necessary.

(ii) Hill slopes are disturbed by developmental works like roads etc. The cuttings at such locations should be properly protected and otherwise stabilised.

(iii) Being in the head-waters of important rivers of the Indus basin, watershed management and afforestation are extremely important and should receive very high priority.

सत्यमेव जयते

14.30. The Central India and Deccan Rivers Basins

The important rivers in this region are the Narmada, the Tapi, the Mahanadi, the Godavari, the Krishna and the Kaveri. The States covered partially or fully are Rajasthan, Madhya Pradesh, Orissa, Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala and the Union Territory of Goa, Daman and Diu. The States of Rajasthan and Madhya Pradesh are covered by the Ganga and the North-western Rivers Basins also. It is not possible to split the States by these Basins, as such these States have been dealt with in a composite manner under the Ganga Basin.

The rivers are, by and large, stable and have well-defined courses. The problem of floods as such is not very severe, although the rivers are in spate occasionally.

Drainage problem arises in the delta areas of the Krishna and the Godavari in Andhra Pradesh and the Mahanadi, the Brahmani and the Baitarni in Orissa. The havoc is serious when floods in these rivers synchronize with high tides from the sea.

Kerala has small rivers, but when, occasionally, in floods, they also cause damage. A number of dams have been constructed on most of these rivers, and some more are in the process of sanction.

The flood problem in general is much less serious in this region than that in the Brahmaputra and the Ganga Basins.

The Union Territory of Goa, Daman & Diu does not have much of a problem of floods. Local problems of sea erosion are tackled by works like sea walls etc.

14.30.1 *Orissa*

The State can be divided into two natural regions, the highland including the hilly parts and the delta areas. Of the many rivers of the State, the more important ones from the flood point of view are the Mahanadi, the Baitarni, the Brahmani and the Subarnarekha.

The Mahanadi used to heavily flood its plains. Since the construction of the Hirakud Dam, however, floods have been moderated. The Baitarani and the Brahmani have a considera-

Baitarni and the Brahmani have a considera-

reaches. The embankments are rather low and not to proper specifications. There are, ther fore, considerable breaches and flooding in th delta areas, more so, when accompanied b heavy precipitation. The overflow of the tw rivers and the Mahanadi, intermingling in th delta region, cause flooding of vast areas fc long periods. The problem is further aggravate when there are high tides in the Bay of Benga After debouching into the plains, the Subarna rekha has flat slopes and many bends and ha also been changing its course. Due to sand bar at the mouth and insufficient capacity of it natural section the river spills over on both side inundating areas in the Orissa-Bengal deltas.

The problem may, therefore, be stated a under:—

(i) Congestion at mouths of rivers due t inter-mingling of waters and a number o cross-channels aggravated by forma tion of sand bars across the mouths, an tidal lockages.

(ii) Existence of private and test relief embankments which are rather low and o insufficient specifications. These breac frequently and also form obstructions t river flow.

(iii) Bank erosion and sand casting in some of the rivers.

Previous committees/experts

Appointed by the State

(i) The Orissa Flood Enquiry Committee, 1959, recommended strengthening of the existing embankments, river training works, protection to towns and villages, sluices to drain off waterlogged areas within the saline embankments, provision of flood storages in the Bhimkund and Salandi reservoirs, and, construction of embankments along the Subarnarekha river.

(ii) The Technical Expert Committee on Cyclones and Tidal Floods, 1971 recommended artificial dykes with afforestation at about 1 km from the sea coast, keeping open the river to other outlets required for efficient drainage of the area, provision of sluices for preventing tides from entering inland, and new drainage cuts in the area subject to drainage congestion.

Appointed by the Centre

(i) The High Level Committee, 1957 suggested—

(a) construction of non-returnable sluices in the flood embankments and drains for depressions in the protected areas.

(b) construction of distribution works at bifurcation points to regulate flows in the various channels of the rivers at the location of their deltas.

(c) construction of the proposed dams on the Brahmani and the Baitarni, supplemented by embankments along these rivers.

(ii) The Subarnarekha Committee, 1972, recommended provision of flood storages in the proposed reservoir at Chandil for flood moderation and embankments in West Bengal and Orissa in a coordinated manner. Improvements of drainage in the lower basins, measures for improving flow conditions, and providing straight cuts to the sea were also recommended.

Measures taken so far

The Hirakud Dam has been constructed on the Mahanadi and has substantially reduced the flood hazard to down-stream areas. Embankments have also been constructed in the outfall reach.

In the Brahmani basin the multi-purpose Rengali project is under construction, this will substantially moderate the floods. New embankments are proposed to be constructed in addition to the existing ones.

A dam has already been constructed across and embankment along the Salandi river, which is a tributary of the Baitarni. These have already afforded a measure of flood protection.

सत्यमेव जयते

Five Year Plan 1978—83

The State has proposed an outlay of Rs. 45 crores for the Five Year Plan against which the Working Group has recommended an outlay of Rs. 30 crores with broad details as under:—

	(Rs. in Lakhs)
(a) Continuing schemes	470
(b) Construction/strengthening of embankments .	1430
(c) Construction/strengthening of Saline embankments	500
(d) Improvement of test relief works taken over by Irrigation Department . . .	100
(e) Drainage schemes	500
Total . . .	3000

Future programmes envisaged by the State

In the Baitarni basin a dam at Bhimkund is projected. This will substantially moderate floods. In addition, double embanking of the rivers is also envisaged.

With regard to the Subarnarekha, an agreement has been reached amongst the States of Orissa, Bihar and West Bengal. A dam will be constructed at Chandil in Bihar, this will afford flood moderation. Embankments are also visualised.

New embankments, raising and strengthening of existing and test relief embankments and drainage schemes are proposed to be undertaken.

Suggestions

(i) In the upper areas of the rivers Mahanadi, Brahmani, Baitarni and Subarnarekha, dams, effecting flood moderation, have either been constructed or proposed. A concentrated effort needs to be made for watershed management and soil conservation; hence there is need for comprehensive provision and programme for this work. The upper catchment of the Mahanadi lies in Madhya Pradesh; hence action in this regard will need to be taken by that State.

(ii) In the middle reaches where embankments have been provided, the countrywide drainage needs attention.

(iii) Test relief embankments are inadequate in height and design. They should be adequately raised and strengthened wherever they could be integrated in the "flood" plans.

(iv) The deltaic areas where the river channels are higher and the irrigated lands are saucer shaped, the following measures are recommended:—

- Spill prevention and improved drainage,
- Change in crop varieties and practices,
- Utilisation of ground water where possible, so that water tables are lowered,
- Effective ban on construction of seasonal bunds and obstructions.

(v) The full volume of water stored at the Rengali storage is proposed to be used for irrigation. In early part of the rainy season, however, half of it is proposed to be kept empty and used for flood absorption and made up in latter half of the season. This type of regulation can be effective only if the monsoon behaves as statistically expected and a rigid filling schedule is followed. Such a planning cannot be completely satisfactory from the angles of both water resources utilisation (viz. irrigation and hydro-power) and flood control. It could result either in being caught by a sudden flood, or, in the reservoir not filling up to the designed level in some years (for example 1979) when the monsoon withdraws rather early.

It is, therefore, suggested that exclusive flood space, wherever possible, be provided in storages.

(vi) As it is proposed to achieve flood moderation from some of the existing reservoirs without ear-marked flood space in them, advance information about the arrival of floods is very helpful for effective regulation. It is, therefore, recommended that arrangements be made for flood forecasting in the catchments of the concerned reservoirs.

14.30.2 *Gujarat*

The State can be divided into three geographical units viz. (i) Gujarat mainland, (ii) peninsular Gujarat (Saurashtra) and (iii) Kutch.

The Gujarat mainland comprises extensive alluvial plains. The important rivers flowing through this region are the Sabarmati, the Mahi, the Narmada, the Tapi and the Banas.

The important rivers flowing through the Saurashtra region are the Shetrunji, the Bhader, the Machhu and the Bhogavo. These rivers merge into the Gulf of Kutch, the Arabian sea or the Gulf of Cambay.

Kutch is an isolated detached area flanked by the Great Rann on the North and the Little Rann in the East and South East.

The nature of the flood problem in the State can be broadly classified as:—

(a) inundation of areas due to inadequate drainage and spilling rivers.

(b) formation of gullies.

Relatively, floods are more frequent in the Gujarat region than in the Saurashtra and Kutch regions. However, some flashy rivers of Saurashtra and Kutch are flood-prone in their deltaic reaches. There is no appreciable problem in the upper reaches due to the barren areas through which they pass.

The rivers that generally cause damage are the Tapi, the Narmada, the Vishwamitri, the Sabarmati and rivers in the Ghed; in recent past floods have occurred in the Mahi also. The tidal nature of the rivers Tapi and Narmada in their lower reaches plays an important role in accentuating the inundation of areas in Surat and Bharuch districts.

Measures taken so far

Only two schemes were undertaken before 1954 (i) The Ghoda Feeder Drain, about 35 km in length, drains Ahmedabad area, benefiting 2834 hectares. The water is led to some small tanks and used for irrigation; and (ii) the Southern Drain, constructed by the ex-princely State of Baroda, about 55 km in length, drains areas of Mehsana district, benefits 3640 hectares and tails into the Sabarmati river.

The following important schemes have been undertaken since 1954:—

(i) Tapi Flood Embankment Scheme.

(ii) Chorvadodara Drainage Scheme (Sabarmati basin).

(iii) Ghed Drainage Scheme (Junagadh district).

The achievements upto-date are as follows:

Embankments . . .	25.8 km
Drainage channels	206 km
Towns and villages protected	40 nos.

The total expenditure upto 3/79 is stated to be Rs. 11.24 crores.

The Chorvedodara Drainage scheme has been completed. The Ghed drainage scheme is still under construction.

The Tapi Flood Embankment scheme started in 1971 is still in progress; the estimated cost is expected to be Rs. 1356 lakhs. The scheme envisages construction of embankments, pitching of river bank, retaining walls etc., in a length of about 40 km. The scheme will spill over to the

Five Year Plan 1978—83

The State has yet to draw up the final plan. The old so-called Master Plan is under review, and it has been stated that the proposed draft Master Plan will be of the order of Rs. 85 to 90 crores. Some of the provisions proposed to be made therein are for the following items:—

(i) Flood warning and flood forecasting system of the State.

(ii) Narmada River Basin.

(iii) Tapi River Basin.

(iv) Mahi River Basin.

(v) Sabarmati River Basin.

(vi) Land drainage works of Ghad.

(vii) Land drainage works of Ahmedabad Gandhinagar, Kheda, Vadodara and Bharuch districts.

(viii) Flood control measures of Vishwamitri and Dhadhar Basins.

(ix) Flood control measures for rivers of Gujarat region.

(x) Flood control measures for rivers of Saurashtra region.

The Plan Working Group has suggested a provision of Rs. 20 crores for flood control works for the above Plan.

It is noticed that a further Rs. 10 crores have been provided for works for prevention of saline ingression. In this connection reference is drawn to the XII meeting of the Central Flood Control Board held on 18-1-1964 according to which inundation of coastal areas by salt water falls under land reclamation. As such this allocation of Rs. 10 crores should not form part of the "Flood" sector.

Future programmes envisaged by the State

As the State has not yet finalised its Master Plan, no details of the long-term future programme are available. It is, however, apparent that the work on the Tapi embankments and the Ghed scheme will continue. The other works will, presumably be, as listed in the last para; specific detailed schemes will need to be prepared.

Suggestions

(i) It is suggested that the Master Plan should be finalised expeditiously, and, priorities drawn up.

(ii) In the meantime, the work on the Ghed project should be completed as soon as possible.

The Tapi embankment project should also be expedited.

(iii) Soil conservation programme should be intensified in all the five watersheds viz. Dantiwada, Mahi, Ukai, Damanganga and Sabarmati.

14.30.3 *Maharashtra*

The problem

The main rivers traversing the State are the Krishna, the Godavari and the Tapi. A small portion lies in the catchment of the Narmada. The west flowing rivers drain the coastal strip termed Konkan.

The rivers have well defined courses, and, are mostly confined within the river banks. It is only in very high floods that they spill over their banks and that too, over small areas and for a short duration of time. Similarly, because of the topography and nature of the soil the problem of rivers changing their courses does not exist. Low lying areas in some towns and cities get affected during the high floods.

Measures taken so far

Due to a limited nature of the flood problem, no major works have been needed. Some town protection works have been completed or are under construction; even these measures are undertaken only where shifting of houses to higher elevation has not been found feasible/economical.

Future programme envisaged by the State

The State has prepared a draft master plan for flood control and anti-drainage works for the various river basins. This is yet to be given a final shape. For the Krishna, the Bhima, the Tapi and the Purna basins, flood control measures at an estimated cost of Rs. 3.87 crores and soil conservation for Rs. 2.36 crores have been proposed.

Suggestions

(i) The flood problem is not acute. All the same, the master plan should be finalised early and works undertaken in a fixed order.

(ii) The pace of work on soil conservation measures is rather slow; the tempo should be increased towards early treatment of all critical areas.

14.30.4. *Karnataka*

The problem

Of the six river systems draining the State, the Krishna in the north and the Kaveri in the south are the major ones. The floods in these rivers are not as devastating as those in the rivers of northern India. However, the coastal districts viz. Uttara Kannada and Dakshina Kannada which are situated in the west flowing river basins, are the worst affected due to heavy rainfall in the area.

The State has a 300 km long coastal line which has problems of beach erosion and migration of river mouths. This problem, however, is dealt with in Chapter No. XXII.

Measures taken so far

The State Government has undertaken a comprehensive approach to land and water resources development of its river valleys; these measures have also helped to ameliorate the flood problem.

Most of the rivers in the State have reservoirs constructed across them as a result of which flood flows have been regulated. Many more irrigation and hydro-electric reservoir schemes are under execution or have been proposed.

Soil conservation and afforestation measures have also been taken up as a long term measure in a number of basins and reservoir projects.

Future programme envisaged by the State

The State has proposed to take up emergent flood protection works estimated to cost Rs. 3.94 crores in different flood affected districts. These are all of small magnitude each.

Five Year Plan 1978—83

The State has proposed to construct embankments totalling 20 km. to provide protection to four flood affected towns and three villages. It is also proposed to take up anti-sea erosion measures for protecting villages situated on the sea shore. Against an amount of Rs. 2.72 crores proposed by the State, the Working Group has recommended an outlay of Rs. 1 crore.

Suggestions

(i) A long range master plan should be prepared identifying all flood control and sea erosion schemes instead of implementing these on piecemeal basis.

(ii) Wherever feasible, chronically flood affected villages should be shifted to higher areas instead of undertaking costly protection works.

(iii) To reduce loss of human lives/cattle as well as movable properties, the State may consider setting up of suitable flood forecasting and warning system.

14.30.5 *Andhra Pradesh*

The problem

Geographically, the State comprises three natural regions: (i) the Eastern Ghats, (ii) the peneplains and (iii) the coastal plains.

The Eastern Ghats are a range of scattered hills which form the boundary between the coastal plains and the peneplained Deccan Plateau. Major rivers like the Krishna and the Godavari cut through the Ghats to join the Bay of Bengal.

The peneplains are part of the Deccan Pateau about 150—700 metres above the sea level.

The Coastal plains between the Eastern Ghats and the Bay of Bengal are over 800 km. long between the borders of Orissa and Tamilnadu States. Rising in the Deccan Plateau, Krishna and the Godavari traverse across this coastal plain. These rivers have been embanked in this reach.

The major problem arises in the rivers originating in the Eastern Ghats, traversing the coastal region. Of these, the principal rivers empty into a natural depression named Kolleru Lake, as the outlet capacity is insufficient, foreshore lands get inundated. The coastal areas are very fertile but being very flat; suffer from drainage congestion. In this region, the main problem is improving the drainage system in the Krishna-Godavari delta, and, lowering the flood level in the Kolleru Lake.

Previous committees/experts

The High Level Committee, 1957 noted the problem of submergence of large areas by the Kolleru Lake and suggested detailed investigations of the Upputeru river and the surrounding drainage area, improving the grade and section of Upputeru, and, investigations about a direct cut from the Upputeru to the Bay of Bengal.

The Ministers' Committee on Flood Control, 1964 noted that inundation caused by the coastal rivers was a pressing problem and that detention basins in their head reaches and embankments in their deltaic lengths were the obvious answers. The problem of the Kolleru Lake and control of its tributaries needed urgent attention.

An expert committee to suggest measures for tackling flood and drainage problems of the coastal districts and lowering the flood level of Kolleru Lake was appointed in 1964. The main recommendations were the construction of reservoirs across Thammileru and Budameru rivers which debouch into the Kolleru Lake, and across the Yerrakalva river, part of which falls into the Kolleru Lake and part in the Upputeru river, as also widening and deepening of the Upputeru river from the Kolleru Lake to the sea and improvements of drains in the Krishna and the Godavari deltas.

Measures taken so far

The main works undertaken before 1954 were the embankments in the deltaic reaches of the Godavari, the Krishna and the Pennar. These embankments have stood reasonably well.

A large number of flood control/protection works of the nature of forming flood banks, protecting villages, ayacuts and low lying areas and construction of drainage channels have been completed in the other ten important river banks of the State.

A number of works in connection with the Kolleru Lake and improvement of drainage conditions in the Krishna-Godavari delta have been completed and some, including improving the discharging capacity of the Upputeru river, are under execution. Investigations of reservoir schemes across the Budameru and Yerrakalva rivers have been completed, further investigations are planned for other works.

The progress achieved upto March 1978 is reported to be as under:

Embankments	398 km.
Drainage channels	5750 km.
Towns protected (upto end of IV Plan)	6 Nos

Five Year Plan 1978—83

The major problem in the State is the drainage congestion in the fertile coastal region. Therefore, the present stress is to relieve the Krishna-Godavari delta and to channelise Upputeru river for draining the Kolleru Lake. Provision has been made in the above Plan for an expenditure of Rs. 22.0 crores on the flood control and drainage schemes in the Krishna-Godavari delta, and Rs. 6.0 crores for the Upputeru Channelisation. A small amount of Rs. 2.0

rores has been provided for the continuing and ew flood control/protection and drainage chemes elsewhere.

Future programme envisaged by the State

The major problem in the State is that of rainage congestion in the Krishna-Godavari elta and the Kolleru Lake, these two areas, herefore, receive priority in the State's future lans. Broad details of a master plan prepared y the State are as under:

	Estimated cost (Rs. crores)	Expenditure upto 3/1978 (Rs. crores)
(i) Flood control/protection works	26.10	
(ii) Drainage schemes other than those Krishna—Godavari Delta and Kolleru Lake schemes .	83.47	22.50
(iii) Flood control and drainage schemes in the Krishna-Godavari Delat-. . .	69.00	35.00
(iv) Kolleru channelisation scheme	31.00	2.80
Total .	229.57	60.30

The Kolleru scheme was so far undertaken s non-Plan, the expenditure so far being Rs. 2.80 rores. It is now proposed to be included in he Plan.

Suggestions

(i) It is clear that the coastal delta region is of great importance to the State. This area also suffers from cyclones as have been experienced n 1977 and 1979. Therefore, the drainage of the Krishna-Godavari delta is of great importance and is supported.

(ii) Steps should be taken to improve the outfall channel of the Kolleru Lake through the Upputeru river.

The other schemes of flood control and drainage may take a lower priority.

(iii) The overall soil conservation is being implemented at a very slow pace. It is recommended that the areas directly benefiting the flood sector should be given priority at a larger annual coverage rate than programmed at present.

14.30.6. *Tamilnadu*

The problem

The major rivers in the State are the Kaveri, the Palar, the Ponniar, the Vellar, the Vaigai, the Tambraparani and the Kodayar. Of these, the Kodayar, the Kaveri and the Tambraparani are influenced by the South West Monsoon and the other rivers by the North East Monsoon. All the rivers have been fully harnessed. It is estimated that about 95 per cent of the surface flows in these rivers are already being utilised for irrigation. Floods in these rivers are, therefore, not of a serious nature and do not pose any serious problem.

The State has also the problem of sea erosion in isolated places, from which serious damages have been reported from time to time. The coast being vulnerable to cyclones, storm surges also affect the coastal areas causing inundation of low lying land with resultant damage to crops and property.

Measures taken so far

As stated earlier, there is no serious flood problem in the State and consequently, no large scale flood control measures have been taken up. Of the few works that have been undertaken, mention may be made of the flood embankments constructed in the lower reaches of the Kaveri. Besides, a large number of irrigation tanks exist in the State. Although these are primarily intended for irrigation purposes, they have considerable flood moderating effect.

The achievements upto March 1977 include construction of 19 km of drainage channels, affording protection to an area of 29,500 ha.

Five Year Plan 1978—83

The States proposals for the Five Year Plan (1978—83) include two continuing schemes namely:—

(i) Drainage schemes in the Kaveri delta.

(ii) Kaveri barrage and other schemes.

The new schemes proposed by the State are:—

(i) Improvement to Chembarampakkan Tank.

(ii) Flood banks to Adayar and other rivers.

Besides, it is proposed to take up anti-sea erosion works in certain important reaches. The Working Group recommended an outlay of Rs. 4.63 crores for the continuing schemes and Rs. 6.00 crores for the new flood control works and anti-sea-erosion works, making a total of Rs. 10.63 crores against the State's proposal of Rs. 18.76 crores.

Suggestions

(i) To prevent disasters caused by breaches in the irrigation tanks, comprehensive schemes for strengthening and maintaining the tanks may be prepared. To start with, the banks of every 5th or 6th tank in the series may be strengthened so as to withstand the pressure of water in case there are breaches in the upper tanks.

(ii) It is reported that there are encorachments in the river Adyar in the vicinity of Madras, these should be removed. Simultaneously, the State may consider enactment and implementation of legislation for land use regulation in the flood plains.

14.30.7. *Kerala*

The problem

The State can be divided roughly into three topographical regions viz:

- (i) The costal belt.
- (ii) The mid-land plains.
- (iii) The heavily forested hills to the west of Western Ghats.

The coastal belt is a narrow strip of land running from the extreme south of the State, north to Kozhikode. The long coast line is subject to heavy erosion during the monsoon months.

The central plains which stretch westwards from the hills are heavily cultivated and intersected by a large number of rivers flowing westwards into the Arabian Sea. Most of these rivers are tidal in their lower reaches.

The hilly area to the west of the Western Ghats is densly forested and traversed by numerous small streams.

There are two types of problems in the State viz. floods and sea erosion. Except in rare cases, the river channels are sufficiently deep in the hilly tracts and middle reaches and normally these reaches carry the flood discharges within high banks. The real problem arises in the coastal belt due to the absence of clear outfall conditions into the sea and the action of tides.

The nature and characteristics of the flood problem in the State may be broadly classified as:—

- (a) Inundation due to
  - (i) Overtoping of banks
  - (ii) Obstruction due to restriction of waterway
  - (iii) Congestion at the outfall
  - (iv) Inadequate drainage facilities
  - (v) Resistance to flow due to tidal action.
- (b) Erosion of river banks.
- (c) Submergence of the road system and disruption of communications.

Apart from the above, the State faces the problem of sea erosion which has been dealt with in Chapter XXII.

Measures taken so far

Flood control measures have not, so far, been taken up according to a comprehensive plan. Piecemeal works have been undertaken in ord to solve local and pressing problems. Wor done have been mainly construction of er bankments to protect thickly populated riv plains and thus save lives/properties. In loc tions of severe erosion, bank protection wor have been carried out by construction of groyn retaining walls, etc.

Achievements upto March 1978, as report by the State are:—

Length of embankments	47 km.
Length of drainage channels	6.35 k
Town protection works	8 Nos.
Raising of villages	2 Nos

Five Year Plan 1978—83

As indicated in a subsequent para, the cost works, out of the outline plan yet to be carri out, is estimated at about Rs. 60 crores. In tl Five Year Plan (1978—83), the State had pr posed an outlay of Rs. 10.00 crores as under:–

(i) Spill-over works	Rs. 2 crores
(ii) Preparation of a master plan of flood control works	Rs. 1 crore
(iii) Maintenance of completed works .	Rs. 1 crore
(iv) Identified works on zonal basis in different rivers	Rs. 3 crore
(v) New works	Rs. 3 crores
Total . .	Rs. 10 crores

Omitting the item of maintenance, the Worl ing Group has recommended acceptance of tł full proposals.

Future programme envisaged by the State

Basinwise flood problems in the State wer studied in detail and an outline plan for Rs. 22.1 crores prepared in 1963.

The present day cost of the works in this ou line plan is estimated at about Rs. 70 crore It has also been estimated that the cost of work already taken up, would be about Rs. 10 crore at current prices. Thus, the cost of works ye to be carried out would be about Rs. 60 crore he break-up of the above mentioned Rs. 70 rores Plan has been given as under:—

	(Rs. crores)
(i) Storage reservoirs	5
(ii) Embankments	10
(iii) Improvement to river channel and inland drainage schemes	30
(iv) Groynes and other protection works	7.5
(v) Diversion and cut-offs	7.5
(vi) Imp ovements of communications	5
(vii) Other items	5
Total	70

The State proposes to take up these works in vo stages of 15 years each.

Suggestions

(i) Completion of spillover schemes, if still ending, should be the first priority.

(ii) The preparation of the master plan should e completed as early as possible and priorities ecified.

(iii) Works already identified in areas which ffer frequent damage should be implemented of priority.

14.30.8. *Goa, Daman and Diu*

The problem

Topographically the District of Goa can be vided into two distinct types of terrain—the vel lands nearer the sea on the west and hilly acts in the east. The terrain is intesected y a number of rivers flowing westwards and scharging into the Arabian Sea. Upper reaches of these rivers lie in region of steep gradients hile the lower reaches lie in low-lying plains. s such, there is no flooding of areas in the upper reaches while the low-lying plains are subct to flooding mostly along banks of rivers beuse of silting of channels. The district is ubject to some sea erosion at places along the oast.

The district of Daman has a flat topography. It is subject to flooding in the same manner as the adjoining regions of Gujarat State. This district also, besides being affected by floods on account of rains, is subject to sea erosion.

The district of Diu, is generally plain and experiences a scanty rainfall of about 20 cm annually. This district is not subject to flooding to any appreciable extent, but has some problem of sea erosion.

Measures taken so far

No flood control or protection works were executed in the territory by the erstwhile Portuguese regime, except some isolated anti-sea erosion works. Even after liberation, the works taken up so far, are mostly of protection from sea erosion.

Five Year Plan 1978—83

The State had proposed an outlay of Rs. 50 lakhs under flood control sector in the Five Year Plan 1978—83 as detailed under:—

		(Rs. lakhs)
1.	Flood control	17.60
2.	Drainage	6.80
3.	Anti-water logging	2.60
4.	Anti-sea erosion	13.34
5.	Machinery and Equipment	0.50
6.	Direction/Administration Charges	2.50
7.	Other expenses	6.66
	Total	50.00

The Working Group has recommended the outlay as proposed by the State.

Suggestions

(i) The territory has not much of a problem of floods. Isolated problems could be attended to, as and when they arise.

(ii) Flood forecasting and warning system for the Damanganga river would be useful for advance warning in a situation similar to that which developed in June 1976.

ANNEXURE 14.1

Potential adjustments to floods appropriate applications, special features and implications for policy making

Adjustment	Appropriate applications	Special features	Implications for policy making
Flood protection	Where the potential losses are large, and particularly where the flood plain is highly urbanized and industralized.	Can often be provided as part of a multiple purpose project, such as a storage reservoir.	Tends to encourage persiste human occupancy and ma create a false sense of securi among those who live on t flood plain. Tends to shift responsibility fro those who live on the flo plain to the public at large. Needs to be supplemented by oth measures.
Watershed management	Where enough runoff remains in the low-water period after the programmes have been undertaken.	Can accomplish multiple objectives by involving forestry and/or agriculture. Is a useful complement to other measures.	Most of the benefits are deriv close to the area where wate shed management is unde taken.
Weather modification	Where external or side-effects are minimal and those adversely affected can be compensated.	Still in a largely experimental stage with over-all effects still somewhat uncertain.	Needs governmental control ensure that the public at lar is protected and that losers a compensated by gainers.
Flood plain management	Where uses other than agricultural and recreational are competing for flood plain land, and especially where they involve urban and industrial uses.	Combinations of structural methods and non-structural methods.	Tends to encourage efficient us flood plains. Responsibility is shared betwe those who live on the flo plain and the regulatory auth rities. Requires a rational basis for sele ting land uses and strong lead ship and public support ensure adoption.
Flood proofing	Where buildings are scattered and frequently flooded, and especially where the depth of flooding is less than three feet, and more than three hours warning is possible.	Structural measures which can be combined with other measures such as emergency action or land use regulation.	Requires a well-organised flo forecasting system aided by flood hazard information pr gramme. Depends largely on individu action and tends to lag intervals between floods.
Emergency measures	Everywhere, but especially where the flood-to-peak interval is greater than one day, the flood duration short and flood frequency high.	A non-structural measure which can be used independently or in combination with other measures.	Requires a well-organised flo forecasting system with clear defined and announced respo sibilities for these functions. Tends to encourage persiste human occupancy. Interest tends to lag when flo frequency is low.

SOURCE : Natural Resources/Water Series No. 5.
Guidelines for flood loss prevention and management in developing countries. United Nations (1976).

XV. PLANNING AND IMPLEMENTATION

15.1. Planning: an imperative need

15.1.1. Floods are a normal feature in this country and have been with us right from the beginning. Man has made efforts to mitigate, if not eliminate, the damage to life and property due to floods. In earlier times, these efforts comprised some kind of embankments or ring bunds round private properties and at scattered places. With the increase in population and pressure on land, this kind of scattered treatment was no longer found adequate. It, therefore, became necessary for the Government to take initiative in this matter and conceive and execute schemes where large areas of land and population were involved.

When such measures at different locations are to be undertaken, some planning becomes necessary, not only to avoid the present process of haphazard treatment of the problem but also with a view to ensure that what is done today does not, as far as possible, create problems tomorrow.

15.1.2. Planning was visualised in the National Policy, announced in the Parliament in 1954. Therein it was stated "Immediate....... This period will be devoted to intensive investigation and collection of data. Comprehensive plans will also be drawn up and designs and estimates prepared for short-term measures of flood protection......" According to the Second Five Year Plan, the outline programme of flood control works drawn up by the then Ministry of Irrigation & Power visualised that the immediate phase, ".....will cover investigation and preparation of plans and estimates."

Starting with the High Level Committee on Floods (1957), the need for planning has been stressed by all technical bodies which have dealt with the problem of floods. Despite such persistent advice, flood works have continued to be undertaken on *ad hoc* basis, as adequate attention has not been paid by the States to the preparation of master plans.

The Fourth Conference of State Ministers of Irrigation, 1979 resolved that ".....the work of preparation of master plans for flood control and drainage..... should be taken up in right earnest and completed within the next four years."

15.1.3. We consider the present practice of undertaking flood schemes on *ad hoc* basis as unscientific and endorse the urgent need of preparing basinwise master plans, also indicating priority of schemes for implementation.

15.2. Water resources and flood plans

15.2.1. Floods form a part of the total water resources of a river. As such, they should find place in the comprehensive planning for water resources development of the basin. The first choice should, therefore, be to undertake comprehensive water resources development of a river basin.

Comprehensive planning of water resources development is, however, a complex matter involving, as it does, collection of extensive meteorological, hydrological, geological and topographical data. Since an overall plan would deal with the complete availability and optimum utilisation of water resources, data would also be required on lands, irrigation possibilities, industrial and domestic requirements, pollution control etc. Strategies like inter-basin links, conjunctive use with ground waters, underground recharge etc. would need to be considered. Collection of such extensive data and proper planning and execution of projects for all river basins would need a lot of time. This could be undertaken only by a well-equipped body like the Central Authority recommended by us in Chapter XVIII.

Floods, however, are a pressing problem which arises every year. It would not, therefore, be advisable to hold over flood plans, pending the preparation of comprehensive plans for the water resources; whenever implemented, these latter would be a positive factor towards the solution of the flood problem.

15.2.2. The policy statement of 1954 visualised that the first phase will extend over a period of two years which will be devoted to investigations and collection of data. According to the Second Five Year Plan, the outline programme of flood control works drawn up by the Ministry of Irrigation and Power visualised that the phase "....will cover construction of long-term storage reservoirs on rivers and tributaries which will in general be taken up along with irrigation and power projects for multipurpose development of the basin."

Proceeding further the Plan visualised "Flood control works selected for a region may, therefore, be such as would conform to the local conditions and afford appreciable protection at reasonable cost." It is, thus, necessary that the flood problem should be dealt with in advance of the overall and multipurpose development of water resources, and, that flood protection measures need not wait till a multipurpose comprehensive project is implemented in the same basin.

15.2.3. A reservoir is the only important hydraulic structure common to overall water development and solution of flood problems, more so, if provision of a flood cushion can be made therein. A storage purely for flood control is generally not an economically viable proposition and none has, so far, been constructed in this country; flood control, therefore, usually forms one of the functions of multipurpose reservoirs. Even so, flood control has been included in very few of the numerous storages so far constructed. Hydraulic structures, useful for other purposes, do not materially help the solution of flood problems.

Storages. however, take long years to conceive, investigate, plan, design and construct. As already stated, they would hardly ever be constructed solely in the interests of flood control but, whenever undertaken, would form an integral part of other types of water resources developments. The solution of "flood" problems, if made contingent on overall development of water resources, would, therefore, be delayed for long years. Whenever constructed, storages will be additional help to the flood protection measures which may have preceded them.

According to the existing orders, the need and feasibility of providing flood space has to be examined for all reservoirs whenever planned for water resources development, and wherever appropriate, incorporated in the design. We reiterate that this direction be faithfully implemented. We also recommend that unless flood control/moderation by a reservoir is visualised within a period of 10 years, its contribution should not figure in the solution of a flood problem at the time it is being considered.

Thus, while reference to future possibilities may be made, solutions for the present flood problems may not be made contingent on assistance from reservoirs visualised for the distant future, but found from amongst the other available alternatives.

15.2.4. Reference, in the past, has often been made to overall water plans and flood plans and common terms have often been used in regard to them. In view of the foregoing discussion, the term "comprehensive" will be used when referring to overall water plans and "master" in relation to flood plans.

Master plans will, ultimately, form components of comprehensive plans. Care should, therefore, be taken that these master plans do not in any way, vitiate or conflict with the future comprehensive plans.

15.2.5. A river basin has been universally accepted as the most suitable and proper unit for preparation of a water plan. As a flood plan forms a part of a water plan, the basin is an apt unit for planning for flood works also.

Flood protection would not usually comprise a single type of measure, covering the whole river basin, but will consist of different types of works to suit different locations in the same basin. Flood protection works quite often influence the regime and behaviour of the river upstream and/or downstream. For proper planning, therefore, it is advisable to visualise flood works which may be needed for different reaches of the river and to analyse and take note of the interaction amongst them. For this purpose also, basinwise planning is a must.

15.3. Soil conservation and afforestation

15.3.1. Excessive sediment load in river may aggravate flood problems by affecting river regime, causing aggradation and change of stream courses etc. In the case of reservoirs, excessive sediment load results in rapid reduction of capacity and hence useful life. Soil conservation and afforestation measures result in reduction of soil loss, and are complementary to flood control/ protection measures.

Floods cannot be entirely prevented by soil conservation measures, although medium floods are, to a certain extent, moderated. The effect of soil conservation measures on high floods is not significant; even so these measures serve the important purposes of preventing excessive loss of soil. Soil conservation is essentially a land development programme, while also complementing flood mitigation measures.

15.3.2. Realising their importance, soil conservation and afforestation measures have already been initiated in the catchment areas of 30 river valley projects as a centrally sponsored programme. The progress so far has, however, been poor and needs to be stepped up.

We recommend that soil conservation and afforestation measures be stepped up not only in the 30 river valley projects, but also in the catchment areas of other rivers, priority being given to those which are flood prone.

15.4. Drainage

15.4.1. The main purpose of drainage for agricultural land is to remove the excess surface water as quickly as possible in order to save the standing crop and, where possible, to make the land available for further sowing. For this purpose, varying standards have been specified by different States, depending upon their cropping pattern, the sowing season, the amount and duration of the stagnant water that the crops can tolerate etc. The ISI has suggested a set of general guidelines and principles for planning and design of surface drains. These are based on the type of factors being taken into account by the States. These ISI guidelines may be considered by each State in the light of local factors and standards specified by areas/region in the State.

15.4.2. Drainage congestion also occasionally occurs behind embankments and at confluences of streams, when the capacity of the drainage sluices is insufficient and/or the water level at the outfall is too high for the stagnant water to drain off. In the former case, increasing the number and/or capacity of drainage sluices may sometimes help; in the latter case, congestion can be relieved only by a fall in the water level of the river at the outfall. Construction of a drainage channel parallel to the embankment, and outfalling into the river downstream, has also been found useful.

Pumping could be a solution but generally much too expensive.

15.4.3. Sometimes congestion of surface drainage occurs due to conditions created by intensive irrigation. According to the Third Five Year Plan, "The cost of drainage works in irrigated areas in the case of continuing and new schemes has to be included in the project costs of these irrigation schemes."

Similarly, sometimes, drainage is resorted to for seasonal reclamation of land in natural depressions

We suggest that drainage schemes of above two types should find place under "irrigation" and "land reclamation" respectively and not in the "flood" sector. However, their effect on the flood runoff downstream should be taken into account in the overall planning for flood control. These schemes should also, therefore, be discussed in the Technical Advisory Committees of the State Flood Control Boards.

15.4.4. In the case of towns and cities, floods or undrained rain water affect communications, damage houses and property, and cause general dislocation. The obvious remedy against floods is protection works of the type and extent justified by the locale. Rain water has to be removed by the drainage system. Provision may be needed for pumping, where storm or rain water cannot find proper outfall at certain times.

15.5. Environment & ecology

15.5.1. In his quest for progress, man has been drastically changing his environment; cutting down forests, interfering with stream flows, creating swamps and waterlogging, polluting bodies of water by industrial and chemical wastes, etc. By excessive abuse, man has upset the balance which nature would, otherwise maintain. He has now realised that by violently changing his environment, he is jeopardising his own survival. This realisation has led to a more pointed attention to ecology or the science of environment.

15.5.2. Water resources development, flood control/protection and drainage measures result in environmental changes. Reservoirs usually result in large scale deforestation, affect the habitat of the local fauna, modify migration, life and type of fish, reduce flows downstream which may deprive lower riparians of water and increase pollution hazard etc.

The High Aswan Dam on the River Nile in Egypt has eliminated floods and provided large amounts of hydro power and water for irrigation. On the negative side, it has resulted in depriving the fields of fertilising silt, reduction of fish catch due to reduction in the quantum of water and silt-transported nutrients at the mouth of the river and caused schistosomiasis, a disease carried by a snail in the reservoir.

Embankments result in changes of velocity and depth of water and deprive outside areas of fertiling silt and land building activities; breaches cause devastation, disruption of life and activities and even lead to stream hanges.

Receding floods leave pools, swamps and generally unhealthy environment which become breeding grounds for parasites carried by vectors to human beings, causing diseases like malaria, filariasis, schistorsomiasis, etc. Polluted waters also result in water-borne diseases like cholera.

15.5.3. Besides providing material benefits, water resources developments yield ecologically positive benefits. Reservoirs provide recreational facilities and scope for improved fish culture. In seasonal rivers, they can be used for flushing the rivers all the year round, thus obviating formation of swamps and pools. Man-made lakes provide habitat for migratory birds and perennial water to wild life of the locality; they can also form nuclei for wildlife sanctuaries.

Similarly, embankments reduce the recurrence of floods and consequential ill effects while providing opportunities for development of the protected areas.

Drainage schemes dry up swamps, thus improving environment and reducing opportunities for breeding of parasites and vectors.

15.5.4. While planning flood control (or any water resources development) projects, it is, therefore, necessary to pay due attention to the pros and cons of the environmental changes likely to be brought about as also the measures that need to be included for reducing the adverse effects of the works proposed.

Where the environmental impact is likely to be significant, advice may be sought from the National Committee on Environmental Planning and Control under the Department of Science and Technology.

15.6. Investigations and collection of data

15.6.1. Any type of planning would require collection of basic data. Data collection was visualised at the time of framing the National Policy; according to the policy statement the immediate phase extending over a period of two years was to be devoted to intensive investigation and collection of data. Such data is essential for preparation of master plans, and, starting with the High Level Committee on Floods, 1957, the need for collection thereof has been repeatedly stressed by various bodies. According to the Second Five Year Plan (1956—61) document, for example, "It is of primary importance that surveys should be completed and necessary data collected to formulate appropriate flood control proposals expeditiously" and, therefore, "A provision of Rs. 60 crores has been made in the Second Plan......including Rs. 5 crores for surveys and collection of data". And yet, according to the Working Group on Flood Control, 1978, "There is no doubt that preparation of master plans calls for collection and analysis of extensive and long-term data, field investigations, detailed studies of various alternatives, etc. Nevertheless this important work does not brook any further delay...." In spite of such repeated exhortation, the Central Water Commission notes "....it has not been possible for the State Governments to give adequate attention to the preparation of master plans. Since preparation of master plans involves collection and analysis of various types of data, very little progress has been made in this direction till today." The Ganga Flood Control Commission has observed that the schemes prepared by the States are not comprehensive, for want of adequate data and information which are reported to be under collection, collation and analysis.

15.6.2. Flood and water resources development schemes have been prepared and implemented over the last 25 years. It is, therefore, felt that a lot of data—particularly, meteorological and hydrological—would have been collected by the States. What is, perhaps lacking is proper collation and basinwise analysis which may now be done. Also gaps, if any, may be filled in and records completed. It is also probable that there is no detailed delineation of areas liable to floods in various reaches of each basin, their extent and crop details. These need early attention.

Detailed contour maps are needed for delineation of areas, working out alternatives, extent of protection, and, land use regulations in flood plains; these are understood to be lacking. Realising the importance of this work, the State Irrigation Ministers' Conference 1979. "...... strongly recommend that the basic work of preparation of detailed contour maps in respect of flood-prone areas be expedited by taking up the work in the Central Sector." We fully support this recommendation.

15.7. Planning

15.7.1. India is an agricultural country. The well being of over 70 per cent of its' population depends upon adequate inputs for successful agriculture, of which water is the most important. Water is a precious resource for development in other sectors also like power, industry, public health, etc. Thus, development of our water resources should have a high priority. Floods, being a part of water resources, its control/mitigation should find a place in such development; the solution, however, cannot await time-consuming planning for overall water resources development.

Flood projects are, at present, being taken up on an *ad hoc* basis. But the logical procedure should be for the flood problems to be examined for each river basin as a unit and master plans prepared basinwise, keeping in mind that they should fit in with the comprehensive plans for the optimum development of water resources. This would obviate selection of crisis-provoked ad hoc projects, and, introduce a basis for selection of projects on systematic priorities.

At the moment, no comprehensive plans for water resources developments, including "floods" have been prepared. An indicative composite plan for water resources, their use and flood control/protection works for the Sahibi Nadi has, however been recently prepared by the CWC. Earlier a master plan for flood control works has been prepared for the Brahmaputra basin by the Brahmaputra Flood Control Commission. The GFCC has also prepared "flood" master plans for some of the tributaries of the Ganga on the basis of the data that the States have supplied and their own studies.

15.7.2. Having collected the necessary data, the planning process should proceed along a series of steps which would deal with the overall basin as well as individual locations liable to flood. Series of steps to be taken are as under:

(a) Assessment of the problem.

(b) Identification of goals.

(c) Alternative measures possible.

(d) Consideration of the criteria to be adopted.

(e) Evaluation of the alternatives.

(f) Decision of a single or combination of alternatives.

(g) Priorities amongst schemes for the basin.

Assessment of the problem

15.7.3. First and foremost, the location and the extent of the problem areas are required to be delineated. Similarly, locations, levels and other features of towns, villages, installations, etc., needing protection are to be detailed.

Important factors in the assessment of the problem would be the magnitude and frequency of floods experienced by the areas/installations proposed to be protected, as also the corresponding damages suffered.

Identification of goals

15.7.4. Depending upon the situation, it is to be considered whether the flood problem would form a part of the comprehensive plan or whether time does not permit waiting for the long-term development plan and whether the flood problem may be dealt with in the form of a master plan.

Considering the individual locations, it will have to be decided whether the scheme is required for protection of irrigated areas or agricultural lands or habitations or industrial installations, etc.

The identification of goals is necessary to decide upon the suitability of the measures that could be considered.

Alternative measures possible

15.7.5. The different methods of flood management have been discussed in Chapter V. The measures to be adopted will depend upon the goals identified, and, the extent and seriousness of the problem. The solution could comprise singly, or, in combination, non-structural measures like change of cropping strategy, modification of susceptibility to flood damage, land use regulations, land treatment, relocation, rehabilitation or living with the floods etc., and structural measures like reservoirs, embankments, channelisation, anti-erosion works, detention basins etc. The suitability of various measures should be considered in relation to the problem at each location and the viable alternative(s) listed for further consideration.

Criteria

15.7.6. A discussion on the criteria for sanctioning flood schemes may be seen in Chapter XIII. Broadly speaking, only technically viable schemes should be prepared. The main criteria would be the benefit-cost ratio, and, the frequency of flooding. Constraint of funds may also enter the picture as one of the criteria.

Evaluation of the alternatives

15.7.7. Having listed the alternative strategies which are acceptable under the criteria laid down, evaluation of the alternatives has to be made. The most important evaluation will be the benefit-cost ratios for the different alternatives. There could, however, be other considerations also for evaluating a single or a combination of alternatives, like the nature and strategic importance of the area/installation to be protected, further potential of the area proposed to be protected, advantages of combining with a developmental scheme etc.

Decision

15.7.8. Decision for adoption, of a single or a combination of alternatives, would be based not only on the benefit-cost ratio, but also other factors like speed of construction, ecological consideration, effect on the life of the population etc.

Priorities

15.7.9. It is not always possible to concurrently execute all the schemes envisaged in the master plan of a basin. Schemes would, therefore, have to be undertaken according to some system of priorities. These may be determined in line with the discussions in Chapter XIII.

15.8. Formulation and processing of projects

15.8.1. In Uttar Pradesh an additional Chief Engineer (Planning) is in charge of overall planning of irrigation and of flood control works. He is assisted by one Superintending Engineer at headquarters for planning and examination and two in the field for investigations and construction of flood schemes. It is also stated that circles in charge of irrigation works also investigate and execute flood schemes falling in their jurisdictions.

In Bihar there is a Chief Engineer in charge of planning of irrigation and flood control schemes assisted by seven Superintending Engineers for investigations and planning, two for designs and one Additional Director in the rank of a Superintending Engineer for irrigation research, with the usual lower formations. The State, however, feels that the setup needs reorganisation. The schemes are executed by the zonal Chief Engineers.

West Bengal is divided into territorial units headed by Chief Engineers of Irrigation and

Waterways Department. The Chief Engineer is assisted by lower formations like Superintending Engineers, Executive Engineers etc. The territorial Executive Engineer is in charge of preparation and execution of all schemes, whether for irrigation, flood control or drainage, only, large schemes in these disciplines are prepared by an organisation placed under a Chief Engineer (Design and Research), with two Superintending Engineers for investigations and planning. In North Bengal the administrative setup is under the North Bengal Flood Commission, with lower formations as per rest of the State. The State considers that the present arrangement for works of short-term nature is adequate. They, however, feel that for preparation of long-term schemes, a special unit may be advisable, although the execution could still be left with the territorial officers.

It will, thus, be seen that in general, there is a unified irrigation and flood control department and a unified setup for investigations, planning and design of works. It is also seen that even where there is a special setup for investigations and planning etc., the territorial Superintending and Executive Engineers also investigate and execute flood schemes located in their jurisdictions.

The question whether the "flood sector" should have an independent setup for investigations, planning and designs depends upon the work load. We recommend that, where the work load justifies, investigations and planning for "flood" schemes may be independent but designs of both flood and irrigation schemes should be entrusted to a unified Designs Organisation in a unified department.

15.8.2. Safety and effectiveness of projects depend upon the details and quality of work which have gone into investigations, planning and designs. It is, therefore, recommended that the staff employed in these disciplines should be adequate in calibre and strength.

15.8.3. Significant funds for investigations of flood schemes are being provided in the Plans. Planning requires consideration of various alternatives which need investigations, collection and compilation of various types of field and other data. It is not always that special organisations have been set up (or even necessary) for the investigations and planning of flood schemes, the territorial Executive Engineers are also being entrusted with this work. Investigations of complicated schemes require field data like subsurface investigations, materials of construction, logistics of transport etc. These investigations take long period and need large funds. It is not possible for the territorial Executive Engineer or equivalent staff to handle such investigations. It is for such types of projects that specialised cells or units have been established in a number of States.

For purposes of carrying out long drawn-out complicated investigations, it is necessary to work on a special estimate. It is only after the viability of the scheme has been established by such pre-project investigations, that the framing of the project and estimates should be undertaken.

We recommend that investigations of extensive and complicated projects be carried out in detail under an "Investigations" estimate. The expenditure so incurred should be included under the sub-head "A—Preliminary" of the Project estimate for purposes of proforma accounting.

15.8.4. The States have powers to sanction projects within the ceiling fixed, other projects have to come to the Planning Commission for clearance. At the State level the authorities are the State Flood Control Board, the Technical Advisory Committee attached to the Board and the Department in charge of the subject. The Brahmaputra Flood Control Commission in Assam and the North Bengal Flood Control Commission, each assisted by a Board of Technical Consultants correspond to the Technical Advisory Committees of the States. The Central Water Commission and the Ganga Flood Control Commission examine the projects submitted by the States for approval by the Planning Commission.

The procedure for processing of projects has been substantially decentralised by the Planning Commission vide letter No. II-16(12)/72-I&CAD dated 8th June, 1973.

According to this procedure, emergent schemes costing not more than Rs. 10 (now raised to 12) lakhs each could be carried out during the flood season and may be sanctioned by the State Government on the recommendation of the State Chief Engineer.

Schemes upto Rs. 50 (now raised to 60) lakhs can be sanctioned by the State if duly recommended by the Technical Advisory Committee and approved by the State Flood Control Board. Proforma details of each scheme, so sanctioned, are to be relevantly supplied to the CWC, GFCC, the Ministry of Irrigation and the Planning Commission.

Schemes costing above Rs. 50 (now 60) lakhs but not exceeding Rs. 2 crores, are to be processed by the CWC and the GFCC, who will send their recommendations to the Planning Commission. The sanction will be accorded by the Planning Commission without having to put up the schemes to the Technical Advisory Committee of the Commission. A list of such schemes, after approval, will be placed before the Technical

Advisory Committee of the Planning Commission for information.

In the case of schemes costing over Rs. 2 crores, detailed project reports will be processed as above and submitted to the Planning Commission, where these projects are to be scrutinised by their Technical Advisory Committee before sanction.

The question of inter-State and international aspects etc. have been taken note of in the directions issued by the Planning Commission.

The States have found this processing procedure satisfactory, except that some of them would like the limit of Rs. 60 lakhs to be raised to Rs. 1 crore and the limit of Rs. 2 crores to be raised to Rs. 4 crores.

A copy of statement 'A' of the proforma in which information is to be furnished by the State Governments to the Planning Commission for schemes costing Rs. 60 lakhs or less each is attached as Annexure 15.1. We have, elsewhere, recommended that the criterion of benefit-cost ratio be adopted for all schemes. In this proforma, however, there is no column for supplying that information. We understand that the benefit-cost ratio is worked out for all schemes prepared by the Ganga basin States. We commend this practice and recommend that benefit-cost ratio should be worked out for all schemes, except emergent ones undertaken during the flood season. Also, that the necessary column be added to the above-mentioned statement 'A'.

15.9 Inter-departmental coordination

We have suggested consideration of non-structural and structural strategies possible of application to specific flood problems and adoption of one or a combination of them. These strategies involve other departments both in planning and later implementation *e.g.* Agriculture for watershed management, soil conservation, cropping strategies, Forest for afforestation and control of existing cover, Irrigation for storages, irrigation in areas after protection, Revenue for land use regulation if planned etc.

It is, therefore, necessary that consultations and coordination be arranged with the departments likely to be concerned|affected by projects at all suitable stages.

15.10 Inter-State rivers

Most of the rivers are inter-State. Water being a State subject, the planning and implementation of schemes is undertaken by individual States. Such uncoordinated action has sometimes resulted in out-of-step construction, and, even nullification of some of the works.

A river basin is the most suitable unit for planning of water resources developments including measures for flood control. It is, therefore, necessary that in order to avoid uncoordinated schemes and avoidable expenditure by way of duplication etc., planning of a river basin be done by an overall Basin Authority. For such purposes, we have recommended, in Chapter XVIII, the constitution of River Basin Authorities, which would, for the present, prepare master plans for "floods". In due course, these could be strengthened to deal with overall development of water resources under the guidance of a Central Authority.

15.11 International rivers

A number of rivers rise in the adjoining countries, mainly Nepal and Bhutan, and flow down into the States of Uttar Pradesh, Bihar and West Bengal. The more important of these are major tributaries of the Ganga which bring down large quantities of floods and silt, aggravating the flood problems in the States of Uttar Pradesh and Bihar. The situation can be mitigated by construction in the head reaches of reservoirs for water resources development, these storages will also moderate floods. There are some sites on the tributaries of the Ganga in Nepal which are eminently suited to the construction of storages and development of water resources for the benefit of both the countries. We urge that negotiations in this regard between the two countries be expedited for joint development of water resources, watershed management, and flood moderation.

15.12 Implementation

15.12.1. The best of plans and intentions cannot yield the desired results unless implemented properly and in time. Implementation has been poor or, at the most, half-hearted in a number of important items.

Starting with the High Level Committee on Floods, 1957 a number of recommendations have been made by various technical bodies, including the Central Flood Control Board (now merged in the State Ministers' Conference). A number of them have not received proper attention.

Most of the recommendations and their status of implementation have been discussed in other chapters of this Report. Here we would only touch upon some of the important items, which have lacked full implementation.

15.12.2. No system of construction priorities appears to be prevalent, with the result that new schemes are undertaken before completion of earlier ones. A number of schemes are thus under execution at the same time, resulting in thinly spread funds and long periods of construction. This practice should be discouraged and projects implemented according to planned priorities and funding.

15.12.3. Although stress has been laid on adequate maintenance for the past 20 years and more, enough funds are still not provided by most of the States. This neglect leads to deterioration, breaches and damage, as also the attempt to carry out normal maintenance from capital funds.

Unless adequate maintenance is assured, it is unwise to continue to undertake new construction and add to the damage potential through their deterioration.

15.12.4. The need for preparing Master Plans for individual river basins/sub-basins needs no repetition. Progress on this item has been poor, and, needs to be accelerated.

15.12.5. The need for soil conservation, afforestation and watershed management has been accepted, implementation is very slow.

While it is important to bring more areas under treatment, measures to stop damage to further areas, as also, to maintain areas already treated, should be undertaken.

15.13. **Funds**

15.13.1. The river is a dynamic entity, and, therefore, some river action will take place somewhere or the other in every season. Such a situation often results in the start of ameliorative schemes. In the absence of master plans and fixed priorities, such *ad hoc* schemes are often the result of local pressures. As a consequence, schemes already under execution are slowed down.

The result is a large number of schemes concurrently under execution and, increasing amounts of spill-overs from year to year. It is understood that in the Five-Year Plan 1978—83, the allocation to the States in the "flood" sector is likely to be about Rs. 760 crores. From the details available vide Annexure 15.2 the spill-over in the States amounts to about Rs. 450 crores (now understood to be about Rs. 500 crores). It will be observed that in a number of States the likely allocation during 1978—83 will not be enough to complete even the schemes continuing at the beginning of the Fifth Five-Year Plan. The total spill-over in the State sector is of the order of 65 per cent. If this state of affairs continues, a stage might be reached where no new scheme could be undertaken in a future Plan.

15.13.2. In order to derive maximum benefit from the allocations to the "flood" sector, it is necessary to follow, after due consideration, the priorities fixed in the Master Plan for the basin/sub-basin. Emergent situations will also arise during every flood season and ameliorative action would need to be taken. Some of these situations may result in formulation of schemes, barring exceptional cases, however, such schemes should rank lower in priority than the continuing schemes.

15.13.3. In the matter of financing, it is recommended that not less than 60 per cent of the Plan and Annual allocations be utilised for continuing schemes and not more than 40 per cent for new schemes and ameliorative action in emergent situations. In States where the cost of spill-over schemes is less than 60 per cent of the proposed Plan allocation, funds should be allocated to emergent and other schemes according to overall priorities fixed in the Master Plan, after fully financing the spill-over schemes.

This kind of disciplined planning will yield better results than at present seen in some of the States.

15.14. **People's participation**

Public participation in projects is very important. Unless people know the benefits and utility of the project, it is not possible to enlist their cooperation. It would, therefore, be desirable if the projects are discussed at the Development Committees level so as to elicit public opinion and also to inform them about the utility and prominent features of the project affecting the people both as far as advantages are concerned as also the inconveniences they may have to bear.

Digging of drainage channels, soil conservation, afforestation, watershed management, land use regulations and flood emergencies are the types of works where involvement of the local population is most valuable, all attempts should be made to achieve such participation.

ANNEXURE 15.1

Proforma in which information is required to be furnished by the State Government in respect of flood control, drainage, anti-water-logging and anti-sea erosion schemes costing Rs. 60 lakhs or less each sanctioned by the States.

1. Name of scheme (attach index map)
2. Name of river, river basin and district in which the scheme is situated.
3. Nature of scheme—whether new embankment, raising and strengthening of existing embankment, drainage, anti-erosion, town protection etc.
4. Length of embankment or drainage channels.
5. Estimated cost.
6. Area benefited.
7. Date of sanction of the scheme.
8. Whether inter-State|international aspect of the scheme, if any, has been examined by the State Technical Advisory Committee and where necessary, clearance of the CW&PC| Ganga Flood Control Commission and the Union Ministry of Irrigation and Power has been obtained.

ANNEXURE 15.2

Statement showing estimated spillover costs of continuing schemes as on 3/78 and likely outlay for the period 1978-83

(Rs. in crores)

S. No.	Name of State	Spillover cost of continuing schemes as on 3/78	Likely outlay for the period 1978-83
1.	Andhra Pradesh	46·24	20·00
2.	Assam	16·05	18·00
3.	Bihar	129·44	122·00
4.	Gujarat	78·59	25·00
5.	Haryana	N.A.	141·00
6.	Himachal Pradesh	0·48	3·30
7.	Jammu & Kashmir	27·52	30·00
8.	Karnataka	3·38	1·00
9.	Kerala	N.A.	20·00
10.	Madhya Pradesh	1·04	5·00
11.	Maharashtra	0·30	0·45
12.	Manipur	0·30	5·00
13.	Meghalaya	0·31	1·50
14.	Nagaland	..	..
15.	Orissa	6·95	15·00
16.	Punjab	N.A.	35·05
17.	Rajasthan	8·08	12·00*
18.	Sikkim	..	0·40
19.	Tamil Nadu	16·01	10·60
20.	Tripura	N.A.	5·00
21.	Uttar Pradesh	25·80	110·00
22.	West Bengal	63·79	145·00
23.	Union Territories	23·38	38·20
	TOTAL	447·66	763·50

***Includes Rs. 2 crores for colonisation.**

XVI FINANCING

16.1. Introduction

Flood control works undertaken so far have been provided free by the Government. The question of recouping a part of the cost from the beneficiaries has, however, engaged the attention of the authorities and various committees from time to time.

The State Governments have drawn our attention to the inadequacy of funds allotted to flood control in the Five Year Plans in relation to the magnitude of the problem. One of the more flood-prone States, Bihar, for example has reported that the planned outlay for the period 1979-80 was of the order of Rs. 18 crores; this was far below the estimated Rs. 24.46 crores required for the continuing schemes. The total requirement of spillover schemes stood at Rs. 110 crores in March 1978. It was further pointed out that out of Rs. 18 crores, a sum of Rs. 9.22 crores was allotted for continuing schemes and only Rs. 8.78 crores for new schemes. The situation in some other States may also be similar.

Out of the outlay of about Rs. 760 crores allocated to the States and the Union Territories for the period 1978—83, about Rs. 500 crores or as much as 66 per cent is likely to be absorbed on continuing schemes. Sometimes, the allotted funds get reduced on account of diversion to maintenance, provisions for which are usually inadequate. This is usually the result of charging maintenance to projects where the construction estimates are not closed for long periods. Some of the States have also complained that the meagre funds get exhausted in meeting the requirements of emergent schemes, thus leaving little for systematically planned ones.

16.2. Raising resources from beneficiaries

16.2.1. *Past and present status*

The Government of India has always been in favour of raising some funds from beneficiaries. As early as 1955, the then Ministry of Irrigation and Power had expressed the view that a special flood cess or betterment levy should be realised from owners of property receiving protection from flood and requested State Governments to give this matter urgent consideration. In fact according to the 1955 guidelines, the willingness of the public to share the cost of flood control works was included as a consideration for taking up of projects and allotting priority. The Five Year Plans have consistently advocated imposition of some betterment levy or cess on areas benefited by flood control schemes; even some target had been fixed in the Third Plan. It appears from the report of the Ministers Committee on Floods (1964) that a proposal to impose betterment levy on flood control works was then under active consideration of State Governments. However, this did not materialise. The Ministers Committee on Floods & Flood Relief (1972) recommended that the States might consider ways and means of raising resources by imposing an annual cess on beneficiaries, both for capital works and their efficient maintenance. In their discussions with us, several functionaries of the State Governments expressed themselves in favour of realising a part of the cost of projects from the beneficiaries.

No action has however been taken so far in the direction of raising resources even though several States have enacted laws in this regard. Andhra Pradesh is the only State which has raised resources through a drainage cess in the Krishna-Godavari delta area where out of an amount of Rs. 36.8 crores targeted, as much as Rs. 27 crores have already been collected.

16.2.2. *Case for raising resources*

One argument that is usually given for not imposing any levy or cess is that beneficiaries of flood control projects are usually very poor people who are not in a position to pay taxes or levies. However, India is a poor country consisting mostly of poor people. Hence this is a general consideration which applies to all taxation measures. As in other cases, this consideration would justify exempting only the poor and not everybody. Certainly the relatively better off in rural and urban areas who are also among the beneficiaries of flood control projects are in a position to share the cost of schemes. There is no social justification in providing flood control benefits as a free gift to well-off beneficiaries out of the general funds of Government contributed by the public at large, which may include people even poorer than some of the beneficiaries. Only the poorer section may be exempted as is already being done in the case of land revenue and other direct taxes. Because of the unequal distribution of property in urban areas, a greater proportion of it is owned by better-off sections. Similarly, in rural areas bulk of the cultivable land is owned by large farmers and not by small and marginal ones. According to the Agricultural census, 15 per cent of cultivators accounted for 60 per cent of the total operational net cultivated area in 1970-71. In view of this fact, exempting the very poor people would not result in any significant reduction of the resources that could be mobilised from the beneficiaries.

Another ground that is given sometimes for not raising resources from beneficiaries is that flood control benefits are not guaranteed. This argument would appear to be fallacious as benefits are derived by partial protection also and it is this which goes into the benefit-cost analysis. Beneficiaries would be required to pay only out of the benefits derived by them and not out of the benefits which could be derived from complete protection against floods. In this connection, it is worth mentioning that in a number of project reports seen by us the benefit-cost ratio has generally been above 2.0 and quite often above 3.0 and sometimes even above 4.0. With such high ratios it is reasonable to expect beneficiaries to pay at least part, if not the whole, of the cost of protection. It may also be pointed out that most of the States have admitted rise in land values, sometimes to the extent of 500 to 600 per cent, after completion of flood protection works. Of course, how much of it is due to flood control and how much due to other factors was not assessed. That flood control has been an important contributory factor has been admitted by almost all the States. It is, therefore, quite fair that a part of this benefit is mopped up by the State.

Benefit from flood control projects being of the nature of avoiding losses is not always obvious as in the case of irrigation which produces visible additional income. Avoiding loss of income is as real a benefit as obtaining additional income.

There is, therefore, no case for exempting beneficiaries from paying for flood control works. On the other hand, there are several reasons in favour of raising some amount from them. Taking up of development projects is a continuing process requiring increasing quantum of resources. Society will find it difficult to spare enough funds for them unless there is a mechanism to recoup at least a part of the cost of earlier projects within a reasonable period from out of the accruing benefits. This is basic to the process of development. Moreover, as the Department of Irrigation has rightly pointed out, the benefits derived from flood control schemes are limited to people of particular localities where the schemes are executed and it would not be correct to charge their cost to general revenues. It would only be fair that the people who are actually to be benefited by the scheme should contribute. As all services are to be charged for, there should be no objection to such a recovery. Moreover, once beneficiaries come to know that they have to pay for the schemes, they would themselves moderate this demand for projects which cannot be justified on economic grounds. This may also exercise some checks on the present practice of overvaluing benefits to show a favourable benefit-cost ratio. Consequently, this is expected to provide a built-in mechanism for a more correct assessment of benefits and costs.

We, therefore, recommend that some resources must be raised from beneficiaries of flood control projects.

16.2.3. *Methods*

The form in which contribution from beneficiaries would be realised should depend upon administrative convenience. We are not in favour of betterment levy in the sense in which the term is generally understood. We feel that it would be extremely difficult, if not impossible, to assess the increase in market value of land and property on account of flood control measures. Instead, it is suggested that beneficiaries may be asked to contribute to the cost incurred on the project. In view of the tradition of not imposing any levy or cess on flood control works, it may not be feasible to recover all costs. Hence the recovery may be phased so that people may be in a position to pay without undue financial strain. We would recommend that a flood cess may be charged for annual maintenance which amounts to 3 to 5 per cent of the capital cost; a start may, however, be made with a cess of 1 per cent. We would further recommend that the amount so collected should be set apart for the maintenance of flood control schemes and not merged in the general revenues.

The cess could be realised either by raising rates of the old taxes like land revenue, property tax etc. or by levying a specific flood cess. The former has certain advantage on administrative grounds. However, we would prefer the latter method as it is more convenient from the point of view of knowing the amount realised, which may be earmarked for flood control works. The creation of any separate administrative machinery for this purpose alone would, however, result in several complications including increase in overhead expenses, multiple filling of tax returns and assessment of tax liability by one more agency. Hence we recommend that the flood cess should be collected along with one of the existing taxes. In urban areas benefited from a project, the cess may be added to the property tax, while in rural areas it may be added to the land revenue. In some States, smaller holdings are exempt from payment of land revenue. The same should apply to the proposed flood cess. Collection should be effected through agencies collecting the taxes of which the cess would be a part.

The following additional points should be taken into account while implementing the recommendation. Since floods do not come often and may not affect the protected area at all, people, though deriving real benefits, may not realise that they are in fact doing so. Hence in the case of new works, it may be expedient to start realisation of the cess with a moratorium of two years. When an existing flood control work is remodelled/modernised/raised/strengthened, a similar cess of one per cent of the cost of the additional work may be recovered from the beneficiaries. Benefits from a flood protection scheme would vary from area to area. In order, however, to keep the system as simple as possible, rates should be fixed uniformally in the State/region.

16,2.4. *Drainage projects*

These works provide direct benefits by way of increased yields and their costs per hectare of benefited area are also lower. The Ministers Committee on Floods and Flood Relief (1972) had recommended that one third of the cost of drainage projects should be realised from beneficiaries. This has not been implemented so far. The feasibility of realising cent per cent of the cost of such schemes has already been demonstrated by Andhra Pradesh. We recommend that as far as drainage projects are concerned the cess may be 3 per cent of the capital cost and the amount recovered should be set apart for maintenance.

16.2.5. *Anti-erosion works*

Where anti-erosion works are constructed to protect industrial installations, roads, railway lines, bridges, etc., belonging to Central or State Governments, panchayat or local bodies, or to protect whole towns and villages, allocable costs may be recovered from the beneficiaries. In cases where such measures are undertaken, at the instance of individuals or group of individuals, allocable costs may be recovered from them.

16.3. Pattern of financing flood control projects

16.3.1. *Practice followed so far*

Flood control, being a State subject, is financed in accordance with the provisions which apply to financing of development programmes in the State sector of the Five Year Plans. The pattern of financing pursued so far may be reviewed in two phases: that followed from the beginning of planning upto 1968-69, and the pattern thereafter. During the first period, there was no uniform pattern of financing; it varied from programme to programme. In the case of flood control works, the Government of India used to provide loan assistance to State Governments which asked for such assistance. The assistance was in the form of 30 year loans, which were interest-free for the first five years.

A change in the pattern took place from the beginning of the Fourth Plan (1969-70) as per decision taken by the National Development Council. According to the revised procedure, the programme-wise pattern of financing was dispensed with and a uniform system of financial assistance from the Centre to the States in the form of block loans and block grants in the ratio of 7:3 was introduced. This system has since continued. The Central assistance during the five year period 1978—83 is also to be provided under this system. A liberal pattern of Central assistance is applicable to Himachal Pradesh, North-eastern States except Assam hills, tribal areas and schemes of North Eastern Council.

Loans given to the States are repayable in 15 annual equal instalments of principal plus interest on the outstanding principal. The amount annually payable, by way of principal and interest, is recovered in 4 instalments each year. They carry interest at 5½ per cent per annum. However, a rebate of one-fourth per cent in the interest is admissible for timely payment of principal and interest or both. In the event of default in the repayment of principal and/or interest, interest is chargeable at the rate of 8 per cent on overdue instalments.

During the last two years of the Fourth Plan, special and additional Plan assistance was provided by the Centre to various States for identified flood control and drainage schemes with a view to accelerating their progress. During the Fifth Plan also, specific provision under the Central sector was made for providing assistance to specific projects. These projects were selected on consideration of the magnitude, extent and frequency of damages, financial position of the concerned State and the requirement of funds in the annual budget. Funds for the above purpose are released to the States on the basis of actual expenditure incurred on the projects. When Central assistance is provided on a matching basis, amounts are released after obtaining physical and financial progress from the States on a quarterly basis. In cases where the entire cost of works is provided as Central assistance, amounts are released after receipt of details of quarterly physical and financial progress.

16.3.2. *More Central funds*

The provision for greater central financing of flood control projects has been advocated from time to time by several bodies. A recommendation to change the earlier pattern of 100 percent loan assistance to States for flood control works in favour of 50 per cent grant and 50 per cent loan was made by the Ministers Committee on Floods (1964) with a view to enabling the States to make better progress during the Fourth Plan. It was endorsed by the Central Flood Control Board in its 14th meeting in February 1965. The above recommendation was reiterated by the Ministers Committee on Floods and Flood Relief (1972) even though the context in which that had been made, namely the sector-wise pattern of Central assistance with cent per cent loan assistance in the case of flood control project had changed from 1968-69. Recently the Action Group on Flood Control appointed by the Department of Agriculture (1978) has also made a similar recommendation.

A strong plea for a more liberal financing of flood control projects by the Centre has been made by almost all State Governments. Several of them have pleaded for a complete take over of flood control by the Centre. They feel that States with their meagre resources were not in a position to cope up with the flood problem which would require massive funds in the next few years if the problem was to be tackled satisfactorily.

16.3.3. *Inter-State rivers*

In the case of inter-State rivers, works that benefit more than one State, have to be carried out; for example, watershed management in the upland catchments of reservoirs, flood component of storages, embankments. drainage schemes etc., which are common to more than one State. The question of financing such common works was considered in the Commission. There were two different views. One view was that the Centre should bear the complete cost of the flood component of reservoirs and upland watershed management which benefit more than one State. The other view was that the beneficiaries/States concerned should bear the cost of common items, proportionate to the benefits derived by them. As the Commission could not come to an agreed viewpoint no recommendation is being made in this behalf. The rationale for the two views are enclosed as Annexures 16.1 and 16.2.

It was, however, agreed that the cost of inter-State works other than upland watershed management and flood component of storages like embankments, drainage, anti-erosion schemes, etc., should be borne by the beneficiary States.

16.3.4. *State rivers*

There is considerable scope for increasing the quantum of Central assistance to States for the works to be undertaken by them under the present financial provisions governing Central assistance to States. In the first place, we note that 10 per cent of the total quantum of Central assistance is distributed amongst the States for tackling certain 'special problems' which include flood control. During the plan period 1978—83 a sum of Rs. 1,325 crores would be available for tackling 'special problems'. It will make a sizeable addition to the proposed flood control outlay of about Rs. 902 crores even if 20 per cent of this amount is allotted to flood control. There is need for tackling the flood problem on an urgent basis so that a major disability of the flood affected areas with respect to their future development is removed as early as possible. We, therefore, recommend that the flood control sector be given preferential treatment, while making allocations from funds meant for 'special problems'.

16.4. Earmarking of funds

16.4.1. Under the old system of financing prevailing prior to 1969, outlays under certain heads of development as also on some specified schemes were earmarked and could not be diverted. This ensured smooth progress of continuing schemes. It, however, is reported to have led to an involved procedure of estimation, intimation and payment of Central assistance which resulted in a complicated system of accounting and delays in financial adjustments. There was thus an increasing realisation of the need to simplify the procedure. Accordingly it was decided by the National Development Council in 1969 that barring certain sectors and schemes such as big irrigation projects considered to be of national importance from the point of view of overall priorities of the Plan, Central assistance would not be related to any specific schemes or programmes This general rule was applied to flood control also. As a result, since then, there is no earmarking of funds for individual flood control schemes.

It is learnt that this practice has led to diversion of funds from one scheme to another on account of frequent changes in priorities brought about by chages in government or key functionaries. Schemes taken up on a priority basis are, sometimes, shifted down and even postponed while schemes undertaken later given preference.

This practice has resulted in delays in completion of projects, increase in costs, loss of welfare, a thin spread of limited resources over a number of projects and taking up of projects beyond the capacity of the Government to finance them within scheduled time.

We would, however. add that, if any at time during execution. a review justifies postponement of abandoning of a continuing scheme, further work on the scheme should be stopped and the project estimate closed. In case of postponement, the work should be brought to a safe stage before the estimate is closed. A fresh project, taking into account changed conditions and costs should be prepared if and when the postponed work is proposed to be restarted.

16.4.2. Earmarking of funds for schemes is expected to take care of this problem. Earmarking implies a commitment to provide funds to continuing schemes on a priority basis and hence it is likely to induce authorities to be more earnest while starting new schemes. Besides. it removes uncertainties regarding the quantum of funds that will be made available in the subsequent years. It has been pointed out by several States that once a scheme is taken up for implementation, funds for it should be provided as determined by the construction schedule so that it is completed within time. There is, thus, a good case for earmarking funds to specific schemes in the flood control sector.

At the same time care should be taken to ensure that earmarking does not result in undue rigidity and non-utilisation of funds. A project for which funds have been earmarked may get bogged down on account of factors like judicial restraint imposed on its execution, unexpected site condition encountered during the course of construction, delay in land acquisition, etc. In some cases, funds are provided in anticipation of sanction which, however, may be delayed for some reason or the other. There would obviously not be any justification for allowing any lapse of the earmarked fund due to a situation which could not have been adequately foreseen. Hence some flexibility may be needed to take care of special situations like the ones indicated above. It is, therefore, felt that the State Government should have authority to divert earmarked funds from one project to another in case of development of a situation which may prevent full utilisation of such funds. However, this should be compensated as early as possible so that projects get completed in scheduled time.

A question arises as to whether the schemewise earmarking should be done by the Central or the State Government. In view of the large number of flood control projects, several of them being local in nature and requiring only small amounts, it is not considered expedient for the Central Government to get involved as this will lead to avoidable accounting, wastage or manpower, and may appear to be an interference in State matters. Earmarking by the Centre will, however, be necessary in the case of inter-State projects. Such earmarking may also be desirable in case of large projects costing more than Rs. 2 crores each and those in advanced stages of construction. In this connection, it may be noted that in the field of irrigation, the Central Government earmarks funds in the case of projects of inter-State nature and those in advanced stages of construction. It is, therefore, recommended that as in the field of irrigation, the Central Government should earmark funds for flood control projects of inter-State nature and for large projects in advanced stages of construction; in the case of other projects, earmarking may be done by State Governments themselves.

Implementation of our recommendation may create some problems for States with a high spillover of projects, specially those having spillover almost equal to or higher than their planned outlay for the next five years. At present, mainly the States of Andhra Pradesh, Assam, Bihar, Gujarat, Jammu & Kashmir, Karnataka and Tamilnadu fall in this category (*see* Annexure 15.2). In such cases, we recommend that till the burden of spillover schemes is over, a limited part of their plan outlay, say about 25 to 40 per cent may be set apart for new schemes and the rest used for the continuing schemes. Alternatively these States may increase their outlay on flood control so as to provide adequate funds for a minimum of new works that cannot be postponed, and for meeting the requirements of the continuing schemes. Perhaps both types of measures may be necessary so as to have a proper mix of continuing and new schemes over a period of time.

16.5. Emergent and normal schemes

In addition to the new and continuing schemes, funds are also needed for dealing with emergency situations during floods. Funds for this purpose should be provided as a first priority out of the flood sector outlay. The existing procedures relating to the sanction of emergent schemes costing not more than Rs. 10 lakhs each (now raised to Rs. 12 lakhs) are expected to take care of this problem.

The occurrence of an emergency situation in a particular locality, however, should not, by itself, be the ground for undertaking a scheme for a long run solution to the problem on a priority basis, resulting in diversion of funds from other schemes or areas. Schemes prepared for a particular locality, after an emergent situation has passed, should be considered along with those for other areas and taken up only according to the priority that it may be given in the overall context.

ANNEXURE 16.1

Reference: para 16.3.3

Central financing—the case for

(1) A significant part of the flood problem is contributed by inter-State rivers. Measures like watershed management and reservoirs which are considered important to flood management have often to be taken, in upper riparian States whereas the benefits of sediment reduction and flood moderation are derived by lower riparian ones also. It will be unreasonable to expect an upper riparian State to take up such measures out of its limited resources for the benefit of lower riparian States. At the same time, the lower riparian States may also be unwilling to pay for the works taken up in other States. Being situated lower down the river they provide an outlet for the runoff of the upper States also. Hence the magnitude of the problem that they face is contributed not only by the runoff originating in the catchment areas within their own States but also by that in the upper riparian States.

Estimation of benefits from watershed measures or a flood control reservoir is a difficult exercise; the apportionment of these benefits to different States, though possible theoretically, would be even more difficult. The difficulties would further increase when an effort is made to make the apportionment precise, for the purpose of cost sharing. This apportionment is likely to be a cause for disharmony and wrangling amongst the States, resulting in delays in sanction and execution of projects which can be avoided if the Centre comes forward to finance such works as it does in a somewhat similar case of national highways. In any case, State-wise break-up of benefits is not necessary for the limited purpose of judging the economic viability of projects based on the benefit-cost ratio.

(2) It is not possible to tackle the flood problem on inter-State rivers in a satisfactory manner without adopting a national approach. If every State starts taking measures without regard to the effects on other States, it may result in uncoordinated planning and inter-State wranglings. It is for this reason that in Chapter XVIII we have made a plea for the establishment of inter-State basin authorities. While this may not necessarily imply central financing, it is more prudent on grounds of efficiency and inter-State harmony if such financing is provided for the flood control component of the common works. In view of the conflicting interests of different States, the dependence of the basin authorities on them for financing works of the type of flood moderation reservoirs and watershed management having effect on more than one State, would subject such authorities to divergent pressures and pulls resulting in indecisions and delays in sanction and execution of such projects, at the cost of people's welfare. A better arrangement from the point of view of facilitating a more unified and efficient control and management of an inter-State river basin would be for the Centre to provide all funds for the flood control component of reservoirs and watershed management measures in such basins.

(3) Besides, central assistance would provide an incentive to States to be willing partners in the establishment of basin authorities, suggested by us. There is no such incentive under the present system of block loans/grants because the States would get their share of the grant even otherwise.

(4) It is felt that watershed management works in the upper catchments which are regarded useful for flood moderation by the Commission may not be considered economical by States on the basis of benefits accruing within their boundaries such as preservation of soil mantle to sustain forest and agriculture, moisture conservation, better land use and increased productivity of land etc. The States concerned, if asked to finance these works exclusively out of their funds, would, therefore, be extremely reluctant to undertake these useful measures and the problem would persist and even increase in the long run. The apportionment of these benefits would not be practicable. The only feasible course is to provide for 100 per cent central grant to cover the cost of flood control component of watershed management measures. However, it has not been possible so far to determine this component. Therefore, 50 per cent of total expenditure on such measures should be borne by the Centre. This is expected to take care of the cost of flood control component.

(5) The difficulties associated with apportionment of benefits in the case of flood control would not arise with respect to irrigation and power. The latter are marketable commodities; as such it is easy to determine the extent of benefits derived by specific areas or States. There is, thus, a clear difference between flood control on the one hand and irrigation and power on the other.

Hence Central financing of watershed management measures and flood control component of inter-State reservoirs would provide no justification for a similar financing for irrigation and power.

(6) In Chapter XIV on Future Approach, we have emphasised the importance of watershed management measures and reservoirs in flood moderation and held the view that wherever technically and economically feasible, these should be the first to be considered. The system of financing should be such as to encourage rather than discourage the increasing adoption of such measures. Finance is, after all, a means and not an end in itself. Without the necessary incentive of the type suggested here, the local approach typified by embankments would continue even in future.

(7) The funds required for implementing the suggestion made here will be a very small proportion of the total Plan outlay of the Central Government. Hence it can be implemented without any significant strain on Centre's finances or without affecting the present pattern of Central/State financial relationship.

(8) It is not without reason that flood control works on inter-State rivers are financed by Government at the national level in most of the important flood-prone countries in the world (*see* Chapter XIX). Even in the United States of America, where the States and local Governments are primarily involved in ameliorative or developmental works, it has been considered expedient to finance flood control by the Federal Government.

(9) Even in our country a more liberal pattern of Central assistance to States has ben followed in the case of flood component of multipurpose reservoirs and watershed management in the catchment of river valley projects. While the cost of several inter-State storage reservoirs, without specific flood cushion like the Bhakra, the Beas, the Bansagar projects, etc., is shared entirely by the States, that of projects having specific flood control components like the DVC and the Hirakud have been shared by the Central Government also. The Government of India have contributed about 50 per cent of the cost of the reservoirs apportioned to flood control in the case of the DVC and 100 per cent in that of Hirakud. Also, 50 per cent of the cost of watershed management measures in the catchment areas of 30 river valley projects taken up as Centrally sponsored schemes have been shared by the Government of India. This is expected to cover cent per cent the cost that could be attributable to flood moderation benefit.

Considering all factors, it is desirable that flood control/moderation works on inter-State rivers giving benefits to more than one State should be financed by the Centre. This should be implemented by the Centre giving 100 per cent grant for the cost of flood control component of a reservoir on such rivers and 50 per cent for the total expenditure on watershed management measures in their upper catchment areas.

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ANNEXURE 16.2

Reference: para 16.3.3.

Central financing—the case against

(1) The principle that the beneficiaries of a project should contribute towards the cost, applies as much to flood moderation reservoirs as to other flood protection measures like embankments, drainage improvement, anti-erosion measures etc.

(2) It is true that some States face more severe flood problem than others, due to various causes such as the pattern of rainfall and the river system flowing through them. Lower riparian States do provide an outlet for the runoff of upper riparian States also. However, these are facts of geography for which neither the upper riparian States nor the Centre is responsible. If the Centre takes responsibility for solving problems like floods which are more acute in some States than in others, it will have to take responsibility also for taking care of problems of droughts, desertification, lack of navigable outlets to the sea, etc. which afflict other States. If there were a unitary form of Government, there would be no problem. In a federal structure like India's, the States must accept responsibility, including financial, for matters within their own sphere.

However, in the case of inter-State rivers, the Centre should ensure cooperation between the States by enacting suitable legislation through Parliament under Entry 56 of List I (Union List) of the Constitution. But this need not necessarily involve Central financing. In several inter-State projects, for example, Bhakra, Beas Unit I & II, Bansagar, Rajghat, etc., the Central Government has played its part in bringing the States together in the planning, construction, and operation of the projects, but the cost is borne entirely by the concerned States. Similar will be the case under the proposed Narmada Control Authority being set up under the recent award of the Narmada Water Dispute Tribunal. Similar to the case of irrigation and power generation projects, it should not be necessary for the Central Government to fully finance the execution of flood moderation reservoirs, in order to ensure unified and efficient control and management of inter-State basins. The existing 30 per cent grant under the present system of Central assistance by block loans and grants is large enough for the purpose.

The proposed River Authorities are intended to be set up not only for flood control, but also for overall comprehensive water resources development. When other components like irrigation, water supply, hydro-electric power generation etc., are financed by the States, in proportion to the benefits derived by them, there is no reason why the same should not be done for the flood control component also. Inter-State harmony can best be ensured by giving full play to States and other local interests to voice their views, with the final decision being taken jointly after free and full discussions with the help of the Centre where necessary. Once a decision is taken, the funds required for implementing the decision should be forthcoming from the States. If certain States, at some time, have a difficulty in their ways and means position, they can be helped by loans from the Centre, other sources or financial institutions like the World Bank. The loans should be recouped out of the State's share of the overall resources. It is agreed that on grounds of efficiency the River Authorities should administer the funds. The present system of block loans and grants can be modified to the extent, that such block loans and grants should be released only after the States concerned fulfil their obligations with regard to inter-State projects.

(3) The premise that areas benefiting from flood moderation reservoirs, cannot be identified, is not correct. In fact, the areas proposed to be benefited can and must be identified by marking the expected limit of floods of various frequencies on contour maps of the flood plain, both before and after the execution of a scheme, in order to work out the benefit-cost ratio, without which the scheme cannot be taken up. Once the areas which are benefited from a project are identified on a map, which also shows State boundaries, there will be no difficulty in assessing the benefits derived by each State, and apportioning the costs.

(4) Reservoirs are generally constructed for multiple benefits. Benefits like irrigation, hydro-electric power generation, domestic and industrial water supply, are all paid for by the use and the State(s) concerned derive(s) revenue from the same. There is no reason why the Central Government should bear the cost of the flood control component, when the revenue earning components remain with the States. Again, if the Centre bears the cost of the flood control component, there may be a tendency on the part of the States, to play down the other benefits in order to charge the maximum possible share of cost to flood control.

(5) Again in the Report, the importance of enforcing flood plain regulations has been emphasised, both in protected as well as unprotected areas, in order to minimise future damage by floods. Flood plain regulations can only be enforced by State Governments. On the other hand, if the Central Government takes over the responsibility for financing flood moderating reservoirs, the States will only clamour for such Centrally financed projects without taking measures like flood plain regulations etc. There might even be a tendency not to consider other measures of flood management which may be better suited in a particular area.

(6) Central financing for inter-State flood control reservoirs will also give rise to demands for Central financing for reservoirs and other works for mitigating the effects of droughts and other similar natural phenomena. This will tremendously increase the financial burden on the Central Government. Since, ultimately the Centre raises resources from the same source, i.e., the population of the States, such increased Central financing will only cause a reduction in the States' share of the country's financial resources.

(7) With regard to soil conservation and afforestation work, the Working Group on Flood Control appointed by the Department of Irrigation in their Final Report (November, 1978), recommended that the "soil conservation|afforestation programme would be complementary to the engineering programme for flood control and should be taken up simultaneously, but it is needless to mention that economic justification of soil conservation and afforestation programmes have to come largely from other benefits, such as preservation of soil mantle to sustain forest and agriculture, moisture conservation, enhancement of fair weather flows, better land use and increased productivity of land etc." Thus, the financing of soil conservation works would not be from the flood control sector.

The direct benefits in prevention of soil erosion and conservation of moisture, thus maintaining and enhancing the productivity of the land, should rightly be paid for by the owners of lands where watershed management works are done. However, as these recoveries may not meet the full cost of works, some State subsidy should continue to be given for watershed management works. The burden of the subsidy should be borne partly by the State in which the work is executed, and partly by the State/States situated within a reasonable distance down-stream, which reap the indirect benefits of the programme. The Centre may bear a small part of the cost in order to maintain the tempo of this important long-term programme, but continued maintenance will not be assured, unless the direct beneficiaries and the State(s) where the work is done, feel that they are involved in the execution as well as financing of the programme.

(8) The provision of 50 per cent grant from the Centre of the total expenditure on watershed management measures for inter-State sub-basins will provide no incentive for watershed management on sub-basins situated entirely within one State, as for example, the tributaries of the Ganga originating from the Himalayas of Uttar Pradesh. That State will be reluctant to spend money on watershed management within the State, unless they also get 50 per cent Central subsidy in the same way as is sought to be given to adjacent States like Himachal Pradesh or Madhya Pradesh.

XVII--MAINTENANCE

17.1 Introduction

As asset that is created needs to be maintained; in the absence of maintenance the asset will deteriorate and perhaps disintegrate.

Storage reservoirs with or without specific flood space are almost always multi-purpose; under daily operation, their regular maintenance usually receives adequate attention. However, other flood protection structures comprising embankments, drainage channels, river training and anti-erosion works do not always receive similar attention. Located where they are, these works are subject to the erosive action of rivers and streams and to weathering by wind, rain, wetting and drying, as also to other factors like burrowing and trespass by cattle and bullock carts etc. Drainage channels are also prone to weed growth and siltation. Unless properly maintained deterioration and disintegration can be fast.

Areas protected from floods attract development of various kinds—factories, roads, railways, etc.—and, increase in human occupancy. Kosi embankments have made possible the Kosi irrigation project; embankments along the Yamuna near Delhi have led to heavy urbanisation. Areas made free from recurring drainage congestion have similarly resulted in increased productivity and development. Any disruption of a protective work, therefore, results in losses of crop, property and installations and dislocation of normal life which are much heavier than if the protective works had not been constructed. Part of the presently reported annual flood damage is also due to failure of some protective works, which is sometimes due to deficient or lack of maintenance.

17.2 Repeated advice

The need for adequate maintenance has been stressed from time to time by various high level bodies.

The High Level Committee on Floods (1957) stated that "…. it is of utmost importance to have satisfactory arrangement for the maintenance and repairs of embankments once these are constructed. No embankment can be expected to survive the onslaught of a river for any length of period if its maintenance is neglected.

According to the Ministers' Committee on Flood Control (1964), "Wherever embankments have been built on a large scale, their adequate maintenance should receive the first attention. This should be considered a high priority task, so that the benefits of the works done so far are reaped in full."

The Ministers' Committee on Floods and Flood Relief (1972) has laid great stress stating, "Adequate maintenance is an essential pre-requisite. At present allocation of funds for maintenance is not sufficient…." The Committee strongly recommended that "….the State Governments should ensure that funds for maintenance as per standards to be fixed are made available," and emphasised that "…any economy in maintenance will be a false economy leading to considerable subsequent expenditure on repairs and restoration apart from danger to the protected areas and population." The Committee further stated that detailed enquiry should be conducted for every breach in the embankments as a routine measure by an officer of adequate status, and the findings of such enquiries be printed and circulated to serve as guidelines for future planning, design and construction of embankments.

The Central Flood Control Board in its Sixteenth Meeting held in November 1977, "…… stressed the need for proper maintenance of flood control, river training and drainage works and requested the State Governments to make available adequate finance for the same…"

The Fourth Conference of State Ministers of Irrigation (1979) "….notes that flood control and drainage works howsoever planned and constructed, do not yield the desired benefit to the protected areas unless they are adequately maintained. On the other hand, lack of maintenance may lead to failures of works resulting in more damage than hitherto…. The Conference, therefore, recommends that the State Governments should allocate adequate funds for maintenance…"

According to the Draft Five Year Plan 1978—83, "In order to stabilise the existing benefits from completed works and also to keep the works in a state of fitness, increased attention would need to be given to maintenance of flood works. States are to be persuaded to provide adequate funds in the annual budget on a certain rational norm."

Despite the importance of proper maintenance of flood works and the serious consequences that may follow its neglect, having been stressed during the last 25 years by all high level bodies concerned with the subject, implementation has remained sadly lacking.

17.3. Measures

17.3.1. Flood prevention and protection measures are needed both in the land and the channel phase. To mitigate sheet-flow and land erosion it is necessary to undertake watershed management and soil conservation both in the up-lands and the plains. Reducing silt load in rivers and reservoirs, these measures are complementary to works undertaken in the channel phase for flood control/protection.

Watershed management and soil conservation measures comprise (i) vegetative and (ii) structural measures. The former includes such works as afforestation, grassland development, horticultural plantation etc. The structural practices comprise bunding, bench terracing check dams, ponds, small reservoirs etc., which are predominantly earthen formations.

In the vegetative measures care and maintenance in tending the plants, replacing casualties, weeding, fencing etc., are needed in the initial 3-4 years before the plantings get established. The structural measures comprising mainly earth formations take some time to get stabilised and special care needs to be taken in their maintenance during the first 3-4 years.

17.3.2. In the channel phase flood control is effected by storage reservoirs behind dams on rivers. The structural measures of protection comprise, by and large, masonry/concrete walls, and, earthen embankments, sometimes armoured along river banks. Ring bunds are used to protect habitations, raised platforms and raising of villages have also been adopted for safety during floods.

Non-structural measures consist of flood forecasting and flood warning systems. Preparedness for emergencies includes maintenance of boats and mechanised craft, transport vehicles, accessible communications, etc.

17.3.3. *Soil conservation and watershed management*

The Forest Departments provide the funds necessary for maintenance on actual basis for the initial 2-4 years in their plan schemes on afforestation and grassland development. Thereafter maintenance funds are met from regular allocations of the concerned departments.

The maintenance of the structural part of soil conservation is the responsibility of the State Governments, under the provisions made in the State Soil Conservation Act, which is in force in most of the States. According to the provisions of this Act, the maintenance of soil conservation structures is the responsibility of the beneficiary, namely, the individual or the community. In case of default, the concerned Department in the State can carry out the necessary maintenance and recover the cost from the beneficiary. In actual practice proper maintenance is lacking, with the result, that structures continue to deteriorate; the main default occurs where the community is the beneficiary. Structures form an important part of soil conservation measures and unless properly maintained the desired results are not obtained from the investment. We, therefore, recommend that in line with the practice for the Plan schemes on afforestation, the cost of maintenance, for the initial 3-4 years, of soil conservation structures at about 4 to 5 per cent of the cost of works should be provided in the original estimates of all conservation and watershed management works. Thereafter the provision of the States' Soil Conservation Act should be enforced and the concerned department should monitor the maintenance programme. Wherever laxity is observed, the concerned department should carry out the necessary works, recovering the cost of maintenance from the beneficiary.

Dams

17.3.4. Not much structural repairs are needed in the case of concrete dams, except to their spillway structures, gates and hoists, cranes and gantries, gauge posts, log chutes, etc. watch has to be kept on the surfaces and joints as well as on the stilling basin down-stream of the dam. Watch has also to be kept in the drainage gallery, and, observations made about the relief of hydrostatic pressure in the foundations. Painting of gates and steel structures and repairs to concrete surface would form the usual items of annual repairs; the annual requirements would be of the order of about 0.25 per cent of the capital cost of the structure. Opening up of foundation relief holes, regrouting of foundations/grout curtains and similar items should be treated as special repairs, not covered under the above provision.

17.3.5. In the case of masonry dams, the most important item is to keep the masonry joints in proper condition so as to obviate leakage across the structure. This requires regular annual pointing, specially on the upstream face. Maintenance of steel structures, spillway and downstream aprons etc., is similar to that of concrete dams; so also drainage galleries, drain holes etc. The annual maintenance requirements may amount to about 0.5 per cent of the capital cost of the structure.

17.3.6. Earthen dams are prone to wear and tear under the influence of the elements like wind and rain. The most important requirement is to keep their crest width and level and the profile as per design requirements. Seepage across the structure may cause sloughing of the downstream face and even settlement of the crest, seepage under the foundations may result in heaving of ground or boils adjoining the downstream toe, a foundation failure may result in settlement cracks across and/or along the structure; careful watch has to be kept for these signs to enable timely remedial action. Galleries foundation, relief arrangements, and, steel structure etc., require similar watch and treatment as for the masonry and concrete dams. The requirements of annual repairs may be of the order of 1.00 per cent of the capital cost of the structure.

17.3.7. In all cases, the downstream regime of the river has to be kept under watch as changed conditions of flow are likely to cause degradation of the bed and erosion of the sides, which may sometimes undermine foundations of the apron and even the main structure.

Embankments

17.3.8. In the main, the requirements of flood embankments are the maintenance of correct crest levels and cross-setions; both these are related to the flood level for which the embankment has been designed. It is, therefore, necessary to maintain a continuous record of the actual flood levels obtained against the embankment throughout its length. A regular annual cross check would indicate the need, if any, for a review of the design features of the embankment. For this purpose gauge posts have to be fixed all along the embankment, generally at regular intervals of about 2 km as also at control points, like regulators, bridges, etc.

17.3.9. As in earthen dams, seepage across an embankment may cause witness of sloughing of the downstream face, settlement of the structure, said boils and/or heaving of land at/adjoining the downstream toe. These are danger signals, which are possible of spotting with proper patrolling and inspection. Emergent and longterm measures should be taken as may be possible in each case.

There is likelihood of leaks developing in the embankment which could be due to burrow holes, termite passages decayed tree stumps, defective campaction during construction etc. Whenever noticed, such points of weakness should be suitably dealt with. As water level rises against the embankment, vigilance has to be exercised to spot any leaks that may develop. Proper treatment of a leak requires tracing its passage across the embankment, and opening and refilling the path with properly wetted and tamped earth. As this operation is not possible during the flood season the leak is plugged and staunched on the water side, and, full repairs could be carried out during the non-flood season.

As another emergency measure, sand bags could be placed round the spot where the leakage water appears downstream. This ring of bags could be raised in height till the water pressure on both sides of the embankment gets equalised, resulting in stoppage of flow.

17.3.10. Sometimes breaches occur in embankments. These could be due to various causes like overtopping of embankment, settlement of the bank, foundation failure, widening of a leak not plugged in time etc. A breach is not a routine item of maintenance, and, has to be treated under a "special" estimate. During patrolling in the flood season, stress should be laid on spotting signs which may indicate possibility of a breach, and taking timely action to eliminate the chances of or at least minimising the probable extent of the breach. Should a breach take place, a full scale operation towards closing it has to be mounted. If complete closure is not possible attempts should be made to at least staunch the opening during the flood season; final repairs would need to be accomplished after the flood season.

17.3.11. Direct attack of the river current against the embankment or near its upstream toe may result in erosion. Emergent measures like dumping of sand bags or stones, trying tree spurs or similar obstructions to divert the current may help. Permanent measures would involve proper study (including model tests if found necessary) and more lasting anti-erosion works.

High winds during high floods sometimes result in strong wave wash against embankments. This has to be urgently dealt with during the flood season. The measures consist of attempts to save the waterside slope from being eroded away and resulting in a breach. Methods like placing sand bags, dumping stones, protection by brushwood matteresses, wooden panels etc., have been tried with succcess.

When designed on the basis of proper hydrological studies overtopping of embankments is rare. The posibility of overtopping can be gauged from a rising trend of the water and information about river flows. from upstream sites. When apprehended, immediate action should be taken towards raising the top level of the bank to above the expected flood level. The usual method adopted is a raised dowla in earth or gunny bage on the inner edge so as to obviate the possibility of water flowing over the crest, resluting in erosion and breach.

17.3.12. As the flood rises, the main attention is to the safety of the embankment. For this purpose, it is necessary to undertake intensive patrolling and close watch so that timely action could be taken as and where needed. It is, therefore, essential to have adequate staff, facilities for patrolling, and, the needed equipment and materials that may be required for patrolling as also for emergency repairs; details have been listed in the Embankment Manual.

17.3.13. Based on hydrological data, and annual observed water levels, the figure of design flood should be reviewed from time to time. The levels and sections of the embankments should be suitably augmented in case of upward revision of the design flood/level. The accuracy of gauge posts should , therefore, be assured by regular checks, and, the posts kept in good repair.

Maintenance, during the fair season, consists mainly of making up the cross-sections and levels of the embankment, filling up rain cuts, clearing jungle, maintenance of turfing on the slopes, closing breaches which could not be fully closed during the flood season, opening up and properly filling leaks which developed and were dealt with only on an emergency basis during the monsoon season etc.

A number of drainage and sometimes irrigation sluices are constructed across embankments. They need regular inspection and repairs to their masonry structures and ancillary components like gates, gate seals, hoists railings etc. Approach and exit channels need to be kept clear of silt, weeds and other obstructions.

Some kind of departmental staff is always needed for general supervision like keeping away trespassers and cattle, safeguarding plantations and attending to minor patch repair works. The other works like making up crest levels and cross-sections, jungle clearance etc., could be done either by departmental labour and/or by contract. The mode and methods can be decided on merits in each case.

17.3.14. All the aspects discussed above have been discussed in the Embankment Manual and A Manual of Food Operations prepared and circulated by the erstwhile Central water & Power Commission. By and large, the States follow the procedures and methods detailed therein.

Based as they are on long practice and experience, we consider that the methods and procedures detailed in the Manuals are adequate and should , normally, be followed.

Ring bunds

17.3.15. Sometimes flood protection measures consist of ring bunds round habitations. This is a measure recently adopted by Haryana. While these ring bunds keep the river water out, there is sometimes a possibility of rain water accumulating within these bunds which is not easy to drain out. To meet such a situation pumps have to be installed. Testing and maintenance of such pumps should be an annual feature so that they do not suffer a failure at the time of need. The maintenance of ring bunds and masonry and steel structures, if any, should be on the same lines as of embankments.

River training and anti-erosion works

17.3.16. These are individual to each location and are not amenable to general treatment. They have to be watched for emergent measures that may be needed during the flood season; complete repairs would be attended to during the fair reason. To meet emergent needs, stocks of materials for repairs should be maintained at critical locations.

Drainage channels

17.3.17. In the case of drainage channels, the most important item of non-monsoon maintenance is keeping the drainage channel clear of weeds, silt and debris, making up the cross-section of banks, closing breaches and cuts, jungle clearance and keeping out trespassers. Tell-tale stones fixed in bed and on top of banks are useful as reference points for levels. Routine maintenance is also required to masonry structures like bridges across drains as also inlets, sluices, gates, gate seals, and other ancillary components. In the monsoon season, patrolling is required to obviate unauthorised tampering with the drainage banks and structures clearing of obstructions to flow, attending to minor repairs and keeping out trespassers. By and large, maintenance is on the same lines as for embankments, but on a smaller scale.

Where drainage of a depression or of land due to unfavourable conditions at the outfall is to be done by pumps, these would need regular maintenance.

To sum up

17.3.18. Manuals can detail only broad guidelines for the work, and men and materials needed. Actual requirements in different States and even different locations will depend upon various factors, like the local climatic conditions, river characteristics, dimensions of the works, high flood levels from year to year, nature of the materials of construction available and similar others. Actuals could be broadly fixed in each State and/or specific locations as found necessary; exceptional situations will have to be treated as such and outside the general norms thus fixed.

Watershed management and land treatment are important adjuncts to flood control measures. We have not come across any literature dealing with maintenance of works in these two subjects. We recommend that maintenance instructions in their behalf may be compiled and distributed for use by the agencies and persons concerned.

17.4. Norms

17.4.1. Embankments and drainage channels being the common types of flood works, have received more attention towards formulation of norms for maintenance in quantitative terms. Other works are more of an individual nature and their needs have to be assessed accordingly; suggestions made on their behalf are only indicative.

17.4.2. Nothing that allocation of funds for maintenance were not adequate, the Ministers' Committee on Floods and Flood Relief (1972) hought fit to lay down a rough guide for maintenance expenditure. The committee suggested a percentage of 4 to 5 of up-dated capital costs as maintenance needs for earthen embankments. For river-training and anti-erosion works, 5 per cent was recommended.

The committee noted that the then maintenance grants included the item of "flood fighting". This particular item is more or less the same as maintenance during the flood season, mentioned in the Embankment Manual. In the present context, therefore, " maintenance" is taken to include the requirements during both the flood and the non-flood periods and no specific mention is made of "flood fighting" as a separate item.

17.4.3. The subject next received attention at the hands of the Sixth Finance Commission (1973) which, in the absence of any other guidelines, based its recommendations more or less on the above-mentioned suggestions of the Ministers Committee. Accordingly it recommended that "keeping in view the present level of maintenance of flood protection works and the constraints of resources it would be adequate if provision for maintenance of flood protection works is made at 4 per cent of the capital costs for the works as estimated at the end of the Fourth Plan".

17.4.4. In 1977, the Central Water Commission worked out another tentative set of norms and placed them for consideration of the 16th meeting of the Central Flood Control Board held in November, 1977.

The norms suggested for earthen embankments was Rs. 7,000 to 10,000 per km at the current price level during the first three years and between Rs. 5,000 to 7,000 threafter. These figures work out to about 3 per cent initially and 2 per cent thereafter of the then prevailing cost of construction. In the case of armoured embankments the annual cost could be Rs. 5,000 to 7,000 per km. In the case of drainage channels, norms of maintenance recommended were according to capacity as Rs. 1,000 per km upto 5 cumecs (200 cusecs), Rs. 1,500 per km for 5 to 15 cumecs (200 to 500 cusecs), Rs. 3,000 per km for capacity above 15 cumecs (500 cusecs). In the case of revetments, the cost would be Rs. 5,000 to 7,000 per km as in the case of armoured embankments. However, in the case of spurs the cost in the first three years after construction may be about 3 per cent and subsequently 2 per cent of the capital cost.

These norms were approved by the Central Flood Control Board. Subsequently these were taken into account and accepted by the Eeventh Finance Commission (1978) for determining the quantum of funds required for maintenance of flood control works. The Fourth Conference of State Ministers of Irrigation (1979) recommended that funds for maintenance should be sanctioned on the lines recommended by the Central Flood Board in 1977.

17.4.5. According to the Central Water Commission, the above-mentioned figures had been worked out on the basis of rough studies made according to the standards of maintenance laid down in the Embankment Manual; the costs would be higher if based on 100 per cent implementation. Suggested as guidelines for discussion in the meeting of the Central Flood Control Board (1977), these figures have, so far, been generally used for estimating maintenance costs.

17.4.6. The maintenance requirements suggested at the rate of 3 per cent during initial and 2 per cent during subsequent years for embankments were based on a construction cost of about Rs. 3 lakhs per km.

The construction costs vary from year to year. The present day costs are much higher than the Rs. 3 lakhs per km assumed at the time (1977) of working out the norms for maintenance, either on the percentage or per km basis. According to some projects approved in 1979, the cost per km works out as under:

Name of the Embankment	Cost
	Rs. lakhs/km
Hazipur-Bazidpur Embankments (Bihar)	10.13
Mahananda Embankment (West Bengal)	12.12
Alipur Bund along left bank of Yamuna (UP)	9.94

It would be observed that a percentage rate based on such costs would mean annual maintenance cost of between Rs. 30,000 to Rs. 36,000 during the first three years and Rs. 20,000 to Rs. 25,000 thereafter. The revised cost (1977) of the Buxer-Koilwar Embankment Scheme (Bihar) works out to about Rs. 17 lakhs per km; the corresponding cost of annual maintenance would thus be Rs. 51,000 and Rs. 34,000.

A part of the rise in the cost of embankments is stated to be because of mechanical compaction now being insisted upon. The "maintenance" on the other hand, involves labour and materials and is to be worked out as far as possible according to the physical norms specified in the Embankment Manual. Though costs of both *viz.* construction and maintenance would be affected by the cost index, the proportionate extent will not be the same, more so whom an element of mechanisation is involved in construction.

It may, therefore, not be practicable to relate maintenance to construction on a percentage basis.

Similar will be the case with regard to drainage channels.

17.4.7. The repairs to river training works like spurs etc., cannot be worked out either on percentage or lump sum basis. These depend upon the action of the river and the damage caused from year to year. The approximate estimates for these could be based only on the experience and judgement of the engineers in charge of such works.

17.4.8. The recommendations made above apply only to the normal maintenance as detailed in para 17.3. and do not cover items like closing of breaches and emergency operations. The allocation needed for plugging of leaks observed in the flood season and left over for repairs during the non-flood season and breaches in the embankments cannot be foretold. It is not, therefore, possible to foresee the exact requirements for such items; only an assessed or token provision can be made in the annual estimates.

17.5. Funds provided

17.5.1. All the States have reported that the funds provided for maintenance of flood works have been far short of requirements. As such, the standard of maintenance of these works is extremely poor.

In Andhra Pradesh, the maintenance funds are sanctioned for the aggregate for all sectors under the Department, wherefore it is not possible to arrive at funds which could be considered specific to flood works. The State has suggested that a separate provision should be made for the maintenance of flood, drainage and anti-erosion works, etc.

In Orissa, the drainage channels under the Irrigation Department are not maintained on account of lack of funds. Furthermore, 3,000 km of embankments are used as highways and the cost of their maintenance is being met from the 'flood sector'. This substantially reduces the already meagre amount provided for maintenance of flood works.

In the Punjab, the actual amounts sanctioned in the budgets have been far less than those estimated by the Department. The departmental expenditure during a number of past years, though very much less than their assessed needs, is higher than the budgetted amounts.

Both the Central Water and the Ganga Flood Control Commission have reported that the funds for maintenance of flood works being sanctioned by the Sates are grossly inadequate and that there are frequent breaches in the embankments for lack of proper repairs and maintenance, causing large scale damage every year.

From a study of the information received, we are convinced that funds being sanctioned by the States are meagre and not sufficient for proper maintenance of works. This has led to inadequate maintenance, and, consequent deterioration of embankments. The result has been not only breaches and heavy damages but also a backlog of repairs, needing urgent attention. If these are not attended to, catastrophic failures involving manifold expenditure on restoration cannot be avoided.

17.6. Consequence of inadequate maintenance

17.6.1. That damages do take place due to failure of protection works like embankments is a known fact; no State, however, has supplied information in this regard. The Ministers' Committee on Floods and Flood Relief (1972) has suggested enquiry into the causes of breaches; it is not known if this is being done in every case. There does not, however, appear to be any year-by-year record of damages in the areas protected which may have been caused, mainly, by breaches in embankments and sometimes by drainage congestion.

While breaches could result from overtopping of an embankment due to higher than design flood levels being obtained in the river, as also due to river erosion, one of the important causes usually is lack of proper maintenance by way not only of annual repairs, but also inadequacy of and slackness in watch and timely action during the flood season.

17.6.2. While a general complaint has been made about the shortage of maintenance funds, it is not, in the nature of things, always possible to exactly pinpoint the consequences of these shortfalls. Some illustrative cases are, however, mentioned below:—

In Assam, "A few embankments which have deteriorated in level and section due to lack of proper and timely maintenance are Neonadi, Dikhow, Desang, Kopili and Pakladiya.

In all the above cases the crest levels got reduced. In case of Desang left bank embankments, the reduction is 1.46 m (average) due to lack of maintenance and side slopes also reduced substantially due to several factors like wind wash, rain cuts, cattle, vehicle movement particularly in reaches passing through populated villages etc."

In Haryana, "...the breaches in Tangri Diversion Bund during the year 1978 causing damage to the surrounding villages as well as the Narwana Branch is clear example of damages due to lack of the proper maintenance of these embankments. The breach in the right bank of Pakasma drain and left bank of the outfall drain No. 8 during the year 1977 were also due to the lack of proper maintenance."

For lack of proper maintenance in Jammu & Kashmir, "....damages both to the flood protection works as well as the private and public property have been taking place in high flood. For the restoration of such damages to flood protection works separate grants are being provided according to necessity, but subject to availability of funds." The cost of such restoration works have been stated to be Rs. 218.50 lakhs during the 1975 floods, Rs. 263.17 lakhs during the 1976 floods, and, Rs. 52 lakhs during the 1977 floods. It is apparent that on account of paucity of funds, restoration of this order of damage could not have been possible so far.

In Orissa, "Due to insufficient fund on repairs, major breaches occurred in 1975 in the Brahmani system."

17.6.3. We have observed that when sufficient funds are not made available for maintenance and repairs of flood control works, one or more of the following methods are sometimes adopted to get round the problem (examples quoted are only illustrative and not meant to be specific);

(i) Repairs are carried out only in very serious situations, thus leaving others unattended to and subject to cumulative deterioration, which would need large sums for rehabilitation at a later date.

To quote the pertinent case of Orissa, "....Drainage channels under the Irrigation Department are not being maintained due to paucity of funds. .....To improve drainage congestion in the State, an amount of Rs. 28.35 crores is required...."

(ii) Capital accounts of projects, though completed, are not closed, and maintenance continued to be charged against the capital account.

In the Punjab, for example, a number of drainage schemes were started in the early sixties and even though the costs are not very high, either a target date has not yet been fixed or specified for the late seventies or later. Even where schemes are stated to have been completed, "project estimates not closed, maintenance is being charged to the project estimates."

Thus, capital costs keep increasing, resulting in reduction of benefit-cost ratio, which with long delays, will tend to become even less than unity.

(iii) Ordinary repairs are carried out under different forms like "stabilisation of the existing benefits", "raising and strengthening of embankments" etc.

In the case, for example, of proposals for raising and strengthening of embankments placed before the 27th meeting of the Board of Consultants to the Brahmaputra Flood Control Commission, Member (Floods), Central Water Commission, "felt that lack of maintenance in the past is responsible for the lowering of the crest level" and that this cost should not be charged to 'capital'. Dealing with this item, the Brahmaputra Flood Control Board, in its eleventh meeting, "... decided that in future adequate maintenance funds must be provided for by the State Government for proper maintenance of the embankments and other flood control measures."

17.6.4. The kind of methods, mentioned above, which are used to get round the problem of inadequacy of maintenance funds, are not correct, and, should be severely discouraged.

17.7. Action suggested

17.7.1. As already stated, the Ministers' Committee on Floods and Flood Relief (1972) considered economy in maintenance as a false economy and enjoined on all State Governments to provide adequate funds.

It is unfortunate that the Committee's views have not received the attention they deserve. As detailed earlier, maintenance funds in almost all the States are inadequate, the probable consequences could be as stated by the Committee. It has not been possible to assess the demages caused on account of inadequate maintenance of flood works but it is felt that they would be considerable.

We would, therefore, urge on all the State Governments to assure adequate funds for "maintenance" of flood works. An immediate start could be made on the bases of norms mentioned in 17.4. These should then be reviewed on the basis of actual needs to be assessed by the Chief Engineer in each State and could, for ease of framing budgetary demands, be on per km. basis overall or for regions or individual works as far as embankments and drainage channels are concerned and, for other works, on an assessed percentage or lump sum basis.

Since prices are changing almost continuously, the norms should be revised periodically so as to correspond to changing costs of labour and materials.

17.7.2. In the case of an emergency like a breach, action has to be taken without delay. To meet such contingencies it is necessary that specified officers in charge of flood works should, where already not so done, be given emergency financial powers and discretionary grants so as to enable them to urgently set in motion measures for dealing with such emergencies.

Such a recommendation was made by the Ministers' Committee on Floods and Flood Relief (1972) and we recommend adoption of this strategy.

17.7.3. It is understood that, from time to time, recommendations have been made that the Planning Commission should insist on adequate non-Plan funds for this purpose, but without much effect.

We are convinced that unless effective action is taken towards proper maintenance of flood works, these assets will progressively deteriorate, resulting in failures and heavy damages; restoration costs will also be high. For these reasons, allocation of adequate funds for normal maintenance is essential, for works interacting between States, this should be mandatory.

We, therefore, recommend that in order to assure adequate attention to "Maintenance", the Planning Commission should take the following action:—

(i) Before granting sanction to annual Plan funds for new and continuing flood schemes, the Planning Commission should assure that the State is making adequate provision for maintenance of existing works, as judged from a comparative statement of maintenance funds recommended by the latest Finance Commission against those utilised in each of the three preceding years.

(ii) It is very important to maintain a proper record of failure of control/protection works including details of damages to crops, property and installations. Results of assessment/enquiry and details of damages etc., in each case of failure should be supplied to the Central Water/Ganga Flood Control Commission each year. A brief resume should be attached with the Annual Plan documents submitted to the Planning Commission.

Submission of such a resume for the preceding year should be the second pre-requisite to sanction of Annual Plan funds by the Planning Commission.

17.8. Some ancillary items

17.8.1. Safety and proper functioning of works like earthen dams, embankments and drainage channels depend upon their maintenance to correct cross sections. The primary work of observations and plottings is usually the responsibility of the lower staff. As the correctness of the data is a vital element for proper "maintenance", it is suggested that suitable checks be exercised by higher officials according to the importance and ruling conditions at each location.

17.8.2. It is very necessary that all points of an embankment (on both if double-embanked) should be approachable at all times. The problem is acute where rainfall is high and earthen embankments become slushy/slippery due to rains. In such cases some kind of a topping like that of moorum or cinders etc., should be a regular feature; a pucca surfacing or creteways or brickways would also be useful.

For facility of inspections, it is also desirable to provide turning platforms at suitable intervals along each embankment. Besides being useful as a crossing and turn-around pace for vehicles, such platforms would also be handy for stacking materials during emergencies.

17.8.3. It is noticed that no specific arrangements exist for tele-communications on flood control works. We are aware that police wireless sets are pressed into service during the flood season in some of the States. It is, however, clear that sufficient number of sets could not be spared by the Police to enable communications from all points of flood works wherefrom messages may have to be sent.

It is, therefore, necessary that arrangements should be made for some kind of tele-communication links from all points of important flood and drainage works connecting them to the headquarters of the superior engineering officers as well as to the control room at State headquarters. This could be in the form of continuous telephone lines, wireless transmission, connection from the nearest public telephone system and so on; facilities existing with the Central Flood Forecasting Organisation could be used wherever practicable.

17.8.4. In certain States like Bihar, natural drainages are not maintained by the concerned Department. In Orissa no attention has been paid to clearance of drains and a situation has arisen where it would require an expenditure of over Rs. 20 crores to clear and put these drains into service.

We recommend that all drains—dug or natural—should be properly maintained up to their outfalls so that drainage congestion is obviated.

17.8.5. In some States, like Orissa, Bihar and West Bengal, a number of sub-standard installations like ex-zamindari embankments and test relief works have been handed over to Flood Control Departments without any specific allocation of funds for bringing them up to standard designs and later maintenance.

It is absolutely necessary, first of all, to upgrade the standards of such works to those applicable to flood works of similar types. For this purpose, specific funds under "capital" or "special repairs" would be necessary. Thereafter regular maintenance funds should be allocated on the same lines as for other similar flood works.

17.8.6. In Orissa 3,000 km. of embankments are being used as public highways without any specific grant from the Highways Department. The maintenance of such embankments needs higher funds per unit length than ordinary embankments for flood protection; such funds should be assured.

17.8.7. In emergencies like breaches, a lot of labour—mostly unskilled—and materials are required and quite often have to be commandeered. We recommend that on such occasions, the engineer-in-charge should take control of operations. He would require assistance from other departments, especially from the Revenue Department, to commandeer additional labour and materials. He will also require assistance from the Police Department and Home Guards to effect control on men and materials. Such assistance should be assured without any hesitation or delay.

There are a number of voluntary organisations in all parts of the country. It is advisable to involve them in such works specially, those who are of the locality; this will give them a sense of participation in the case of a work which renders protection to their lands, life and property.

17.0. Training

The main stress of maintenance is during the flood season when intensive patrolling is needed. The broad requirements are ability to spot points of incipient danger and take timely action. For success, it is necessary that the maintenance staff be trained to recognise signs of danger, and, understand the immediate action that should be taken or set in motion.

The main persons involved are the unskilled labour, the supervisory staff like the works sarkar and the works mistry, the overseers and the Assistant Engineer. They should, therefore, be put through a well-planned training drill. The training programme could best be conducted on emmankments in non-flood and early part of the flood seasons, including practical experience for items like opening up and repairing leaks, closing a breached section, repairing of river training works etc.

The actual closing of a breach during the flood season itself is a very valuable experience. In such a case arrangements should be made for visit to the site by as many engineering "flood" staff as possible, without coming in the way of the closure operation.

Another effective means would be exhibition of films of actual maintenance operations and action during emergencies like closing of a breach or plugging of a leak. This in fact, should form a compulsory feature of the training programme.

Services of home guards and voluntary organisations would also be requisitioned under certain conditions. They should also, therefore, be included in suitable programmes of training.

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XVIII--ORGANISATION

18.1. Introduction

18.1.1. The programme of flood management has to be evolved and implemented keeping in view the aim of optimum utilisation of water resources of the country. For achieving this goal, adequate organisational set-ups are needed at the Centre and in the States.

18.2. Central Organisations

18.2.1. In 1954, when for the first time the flood programme in the country attracted serious attention of the Government of India, a Central Flood Control Board was constituted to draw up a comprehensive plan of flood control with the following functions:—

- (i) To lay down general principles and policies in connection with flood control measures;
- (ii) To consider and approve Master Plans for flood control submitted by the States/ River Commissions; and
- (iii) To arrange for necessary assistance in connection with planning and execution of flood control works.

As a decision of the Central Flood Control Board in 1954, a Flood Wing was added to the then Central Water and Power Commission; the Flood Wing served as the Secretariat of the Central Flood Control Board.

In 1977, it was decided to merge the Central Flood Control Board with the Conference of State Ministers of Irrigation. This Conference comprises the Union Minister in charge of Irrigation as Chairman with Ministers of Irrigation and/or Flood Control in the States as Members; the flood control work in most of the States is handled by the Irrigation Departments. The first meeting after the amalgamation of the Central Flood Control Board with the Ministers' Conference was held in February 1979.

18.2.2. Under the apex body of the then Central Flood Control Board, four River Commissions, namely, the Ganga, the Brahmaputra, the North-western and the Central India River Commissions were set-up during the fifties, mainly, with the purpose of preparation of integrated plans of the river basins and ancillary matters. These Commissions have become non-functioning bodies now.

The Ministers' Committee on Flood Control, 1964, suggested that the River Commissions should be substituted by Regional Flood Commissions and suggested four Commissions, namely, the Ganga, the Brahmaputra, the North-west and the Central India and Deccan Rivers Commissions. The proposal of the Ministers' Committee was not, however, accepted by Government.

18.2.3. The Flood Wing of the Central Water Commission is now headed by a Member, assisted by one Chief Engineer in charge of the Central Flood Forecasting Organisation and ancillary lower staff. It deals with matters pertaining to States other than those which fall within the jurisdiction of the Ganga Flood Control Commission.

The functions of the Flood Wing are:—

- (i) to provide guidance in the preparation and scrutiny of:—
    - (a) Flood control schemes prepared by State Governments for consideration and approval by Technical Advisory Committees;
    - (b) Draft Master Plans;
    - (c) Irrigation and multi-purpose schemes with regard to adequacy of flood control, drainage, anti-waterlogging and anti-sea-erosion.
- (ii) planning and establishment of flood forecasting systems,
- (iii) to coordinate and act in liaison with various authorities in processing and execution of flood control, irrigation, drainage and hydro-electric schemes in the Union Territories.
- (iv) to guide the Damodar Valley Corporation in discharging its function in relation to the releases of water from the DVC dams.

18.2.4. The Brahmaputra Flood Control Board was set-up in 1970 under the Chairmanship of the then Union Minister of Irrigation and Power. The Board is a high-powered policy making body which decides priorities in the implementation of various flood control schemes, etc.

18.2.5. Following the floods of 1971, the Ganga Flood Control Board was set up in 1972, to deal with flood problems of the States in the Ganga Basin, with the Union Minister in charge of Irrigation as Chairman. The Board is to lay down broad policies and decide priorities for implementation of schemes. The Board was to accord pproval to schemes and recommend outlays, t now the final approval and allocation of nds are done by the Planning Commission.

Concurrently the Government of India set up e Ganga Flood Control Commission for dealing ith flood problems of the States in the Ganga sin. A copy of the Constitution of the Commission, as originally framed, is attached as Annexure 18.1. This has since been modified and ems (iii), (v) and (vii) have been withdrawn rom the duties of the Commission. Items (iii) nd (vii) are entirely within the jurisdiction of he States and item (v) is the function of the entral Water Commission. The work of technical examination and recommendations to the lanning Commission of schemes in the Ganga asin, was added to the Commission's duties in 973.

18.2.6. Flood forecasting has become an important aid to measures dealing with floods. A Central Flood Forecasting cell under the then Central Water and Power Commission was set up for the Yamuna River in 1959. The forecasts endered by this unit were found to be extremely useful and helpful in giving timely warning f impending flood events; the work of flood orecasting has since been extended as a result of the review by the Ministers' Committee on Floods and Flood Relief, 1972. Coverage of more reas is under way.

8.2.7. *Autonomous Organisations*

There are two organisations set up under Acts of Parliament viz. The Damodar Valley Corporation and the Bhakra-Beas Management Board. These two organisations are entrusted with the task of regulation of the storages on the Damodar and the Sutlej-Beas rivers respectively taking nto account the interests of user functions and user States.

18.2.8. The Damodar Valley Project was conceived at the close of the Second World War amdist famine, flood and frustration. The Damodar Valley Corporation was set up under an Act of Parliament in 1948 for the development of the Damodar Valley. The project drew inspiration from the Tennessee Valley Authority in the United States of America. According to the Act, the functions of the Corporation were:—

(a) the promotion and operation of schemes for irrigation, water supply and drainage;

(b) the promotion and operation of schemes for the generation, transmission and distribution of electrical energy, both hydro and thermal;

(c) the promotion and operation of schemes for flood control in the Damodar dar river and its tributaries and the channels, if any, excavated by the Corporation in connection with the scheme and for improvement of flow conditions in the Hooghly river;

(d) the promotion and control of navigation in the Damodar river and its tributaries and channels, if any;

(e) the promotion and afforestation and control of soil erosion in the Damodar Valley; and

(f) the promotion of public health and the agricultural, industrial, economic and general well-being in the Damodar Valley and its area of operation.

18-2-9. The Bhakra Management Board was constituted under Section 79 of the Punjab Reorganisation Act, 1966, for the purposes of administration, maintenance and operation of the Bhakra dam, reservoir and appurtenant works, hydel stations and irrigation installations etc.

The functions of the Bhakra Management Board include the regulation of supply of water to the States of Punjab, Haryana and Rajasthan, regulation and supply of power generated at the power houses under the Bhakra project, construction of the remaining works and such other functions as the Central Government, after consultation with the Governments of the concerned States, may entrust to the Board.

Under Section 80 of the said Act, similar functions with regard to the Beas project also were entrusted to the Bhakra Management Board, which was renamed as the Bhakra-Beas Management Board.

Significant flood moderation is achieved by judicious reservoir operations during the flood season.

18.3. Set-ups in the States

18.3.1. Water being a State subject, the States have to investigate, plan, construct, maintain and operate all flood works. In line with the Central organisation, Flood Control Boards were concurrently set up in some of the States, later followed by some others.

The functions of the State Flood Control Boards are to assess the flood problem in the States, deal with questions of policy and oversee the planning and implementation of flood schemes. In the discharge of their functions, the Boards are assisted by Technical Advisory Committees.

18.3.2. The operating organisation is the Department, mainly the Irrigation Department, which may or may not have a separate wing dealing only with flood control. The Ministers' Committee on Flood Control, 1964, had stated "....that at least in the States with serious flood problems proper flood control departments should be organised under a Chief Engineer with appropriate number of regular field circles and divisions to look after investigations, construction and maintenance of flood control works as distinct from the regular Department."

18.3.3. Referring to the question of a suitable set-up for dealing with flood sector, the States of Bihar, Haryana, Karnataka, Maharashtra, Tamil Nadu, West Bengal, Goa, Daman and Diu have stated that the existing arrangements of the Irrigation Department handling the "flood" sector also are satisfactory. Bihar has recently appointed individual Chief Engineers according to river basins, to look after irrigation, flood control and drainage in respect of the river basins in their charge.

The States of Andhra Pradesh, Gujarat, Madhya Pradesh, Manipur, Rajasthan, Tripura, Kerala and the Union Territory of Delhi have found the existing arrangements satisfactory with the Irrigation Department looking after the flood sector as well, but have suggested strengthening by extra circles and divisions specifically for flood works.

The three States of Punjab, Orissa and Uttar Pradesh have suggested separate departments for floods. In the set-up proposed by Uttar Pradesh, the zonal "flood" Chief Engineers have also been given the responsibility of estimation of water resources in their respective zones.

The State of Jammu and Kashmir has set-up a separate department for dealing with floods. In Assam, the Brahmaputra Flood Control Commission, assisted by a Board of Technical Consultants, both set up by the State, handles the work.

It would, thus, be seen that the pattern of the set-ups for dealing with floods in the States is not uniform.

18.4. Inter-state rivers

18.4.1. A number of States have suggested a set-up of some kind of an inter-state body for planning, coordination and even execution of flood works on inter-State rivers.

Most of the States have stated that the Centre should take over the responsibilities in the matter of flood control in the States. The full implication has not been spelt; the main intention, however, appears to be that the Centre should meet most of the costs of flood control/protection.

18.4.2. A river basin, including tributaries, has now been accepted as the proper unit for development of water resources. The same applies to "floods", which are a part of water resources. No State by itself can visualise a plan for an inter-State river. Even in the case of intra-state tributaries, it is advisable to dovetail their development with that of the main river in order to achieve economy of scale and coordinated development.

An inter-State river can be satisfactorily dea with either by a joint body of the concerne States or by a Central body in consultation wi these States.

While some inter-State problems have bee solved by mutual discussions amongst the Stat concerned, there are long delays and many pr blems persist. Further, such a procedure wou not appear to be quite feasible in the case rivers like the Ganga with its numerous tribu taries and covering a number of States. It i therefore, necessary that there should be a re sonable extent of Central association with gui ance in the matter of development of inter-Sta rivers.

18.5. Functioning of basin organisations

18.5.1. The basin organisations at present fun tioning in the country have not been fully su cessful in discharging the duties allotted them.

The Damodar Valley Corporation, for exampl was constituted with great hopes. During ou discussion with the Chairman and officers of th Corporation, however, we formed the impression that in the existing situation it was impossible for the DVC to work as a self-relian authority, mainly because, interests of the part cipants associated in the DVC were not identica Also, the interests of flood control, irrigation an power generation are in conflict with one ano ther. It was also mentioned that measures lik taking over of irrigation by the West Benga Government and the construction of Tenugha dam by Bihar are examples of how the authorit of the DVC has been diluted. It was also learn that financing of the Corporation by the thre participants (viz. the Centre and the two States has not been satisfactory. It was, for example stated that there was no additional contributio from the States for expansion of the power sector and that the Corporation had to resort t market borrowing, guaranteed by the Centre.

18.5.2. The Bhakra-Beas Management Board i responsible for the upkeep of the structures an regulation of the storages on the Sutlej and Bea rivers. Although there is no specific floo cushion in the Bhakra Storage, it is but natura that the Board should co-ordinate with the Punjab State during the flood season, so that regulation by the Board does not harm the interests of the lower riparian areas as far as can be avoided. All the same, during the 1978 floods, controversy arose between the Board and Punjab, the latter complaining against untimely release from the Bhakra Dam, and the forme justifying them on the grounds of the safety o the Dam.

The Board has also been handicapped for lack of control in watershed management. In fact although they have acquired land between elevations 1680 and 1700 feet (504—510 meters) fo eating a green-belt, the same has yet to be ıplemented on account of a lot of unauthorised ıltivation being done in that area which lies in imachal Pradesh.

18.5.3. The Yamuna Committee was constituted coordinate floods plans along the Yamuna ver amongst the three riparian interests of ttar Pradesh, Haryana and Delhi. But it has ɔt been able to exercise effective coordination ıd control on the works being carried out by e three riparians in their own territories.

18.5.4. The Ganga Flood Control Commission as charged, amongst others, with the responbility of preparing comprehensive plans, to get ıe works implemented in a co-ordinated manner ensure proper standards of construction and assess the performance of flood control meaıres. The Commission has been hampered in chieving these results on account of lack of suply of data by the States, and the lack of authoıty to ensure coordinated implementation, and roper standards of construction and maintenance s also for assessing performance of works.

18.5.5. It would, thus, appear that in order to e effective, the central participation should ave adequate authority to implement the manate given to it.

8.6. Past measures

18.6.1. The premise that the whole river basin hould be treated as a unit of development, has een accepted all over the world. In an intertate river, the interests of the States concerned re likely to be diverse (as for example in the)amodar Valley area) and give and take becomes ıecessary. There is also need for taking an verall and co-ordinated view of the whole river. t is, therefore, necessary to constitute riverwise authorities with wide enough functions and owers to satisfactorily plan and achieve deveopment of the various aspects of water resources f inter-State rivers.

18.6.2. The River Board Act of 1956 was the irst attempt at setting up of a coordinating body f this nature and came into force in May 1957. According to the Department of Irrigation, "The uestions such as providing finances for the unctioning of the Boards, scope of their work is-a-vis existing agencies, etc., remained under liscussion till 1961. Ultimately it was decided hat to begin with River Boards should be set ıp for the following rivers...."

Continuing, it is stated that, "Section 1 of the River Boards Act, 1956 provided that the notifiation setting up of River Boards should be isued only after consultation with the State Governments interested....As most of the States did not agree with the proposal, no River Board has been set-up."

18.6.3. Recently, the Brahmaputra Board Bill, 1979 has been framed for the main purposes as follows, "(1) Subject to the other provisions of this Act and the Rules, the Board shall carry out surveys and investigations in the Brahmaputra Valley and prepare a Master Plan for the control of floods and bank erosion and improvement of drainage in the Brahmaputra Valley.

Provided that the Board may prepare the Master Plan in parts with reference to different areas of the Brahmaputra Valley or with reference to different matters relating to such areas and may, as often as it considers necessary so to do, revise the Master Plan or any part thereof.

(2) In preparing the Master Plan, the Board shall have regard to the development and utilization of the water resources of the Brahmaputra Valley for irrigation, hydro power, navigation and other beneficial purposes and shall, as far as possible, indicate in such plan the works and other measures which may be undertaken for such development."

We feel that Master Plans for floods need not await comprehensive planning for water resources. If the comprehensive plan is not prepared, other flood protection measures in the basin should be carried out, keeping in view the overall development of the utilization of the water resources in the basin.

18.6.4. A strategy is, therefore, needed which would ensure progress of flood schemes even when more than one State is involved, and in such a way as not to vitiate future comprehensive planning for development of water resources.

18.7. River Basin Authorities

18.7.1. In a vast country like ours where most of the flood prone basins are inter-State, attempts by individual States to tackle the flood problems cannot succeed. The very fact that the river is an inter-State one raises innumerable problems of ad hoc measures for flood protection are taken by individual States. The problems may be technical as well as legal. The co-riparian States' rights may be adversely affected, or the protection works by one may have adverse effects on the neighbouring State or States. After a careful consideration of all these factors, the Commission has come to the conclusion that the river basin is the most convenient and appropriate unit for purposes of implementing flood protection measures. The Commission has also had the benefit of hearing the views of some of the eminent engineers of the country and of consultations with representatives of the State Governments. They have, by and large, suggested that the river basin would be the most appropriate and suitable unit for the purpose of flood protection measures. We, therefore, recommend the setting up River Basin Authorities.

18.7.2. We have in a later para, suggested the setting up, in due course, of a Central Authority, with the function of planning optimum utilisation of water resources of the country, framing national policies for the overall water management and taking decisions in matters related to water.

We recommend that the River Basin Authorities may be constituted for the different river basins as under:

(1) *Western River Basins Authority*—covering the Narmada, the Tapi, the Mahi, the Sabarmati, the Banas and their tributaries;

(2) *The North-West River Basins Authority*—covering the Jhelum, the Chenab, the Ravi, the Beas, the Sutlej and their tributaries;

(3) *The Ganga Basin Authority*—covering the main Ganga upto its outfall into the sea, and all its tributaries including the Yamuna and others from the north and the south;

(4) *The North-East River Basins Authority*—covering the Teesta, the Brahmaputra, the Barak and their tributaries;

(5) *The Eastern River Basins Authority*—covering the Mahanadi, the Brahmani, the Baitarni, the Subarnarekha and their tributaries; and

(6) *The Southern River Basins Authority*—covering the Godavari, the Krishna, the Pennar, the Kaveri and their tributaries.

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18.7.3. The usual staffing pattern for each Basin Authority would conform to the following wings:

(i) Planning;

(ii) Design and technical examination;

(iii) Co-ordination, evaluation and monitoring of works and of maintenance.

To be effective, the Authority must be adequately staffed at all times; delays in one or the other function will result in infructuous cost in most of others staff.

It is recommended that the personnel are drawn from multi-disciplines—such as engineering, economics, agronomy, ecology, public health etc.

18.7.4. For the resent, the functions of the Basin Authorities would be as under:

(i) to frame and issue guidelines for preparation of projects and to scrutinise, for further processing, flood control/protection schemes, prepared by the State Governments;

(ii) to prepare basin-wise maps and inventories of water resources in the basins, including details of areas liable to floods, protectable areas and areas protecte and, keep the same under continuous r view. In the areas liable to floods, d tails should also be kept of areas alrea irrigated and areas which have a pote tial for future irrigation;

(iii) to advise the States about the prioriti and needs of areas to be protected a suggest preparation of plans;

(iv) to prepare flood control/protecti master plans for the allotted river basi keeping in view the overall water r sources development of the basin.

This would need collection, compilation a processing of various types of data. The Stat at present prepare their own flood control/pr tection plans and collect the necessary data e The States should continue to do so, and whe required supply the same to the Basin Authori

(v) to prepare annual State-wise progra mes of works and priorities;

(vi) to assess and recommend State budg tary proposals which should be rout through the Basin Authorities;

(vii) to assess the performance of flood co trol/protection measures, and prepa annual reports;

(viii) to monitor construction in order to e sure implementation of the works to pr per standards and time-schedules;

(ix) to monitor the functioning and maint nance of works and bring to the noti of the States, deficiencies, and sugge rectification where necessary; and

(x) to undertake observations, investig tions and construction only where abs lutely necessary.

18.7.5. We have used the word "for the pr sent", because ultimately we envisage that the River Basin Authorities along with a Centr Authority which we are suggesting will be t organisations whose functions will be to plan f the maximum utilisation of water resources, frame national policies with regard to wat management of the country as a whole and take appropriate decisions in this behalf.

The functioning of the Basin Authorities wi not be restricted only to the flood sector, but the overall water resources development/man gement of the country. It is, therefore, nece sary to have an apex body at the Centre whi would co-ordinate the working of these vario Basin Authorities. We would, therefore, su gest that a Central Authority may be constitute in due course of time with the Prime Ministe as the Chairman, the Union Ministers of the d partments concerned, the Chief Ministers States, and Heads of Union Territories as mem bers. This apex authority should be assisted b a strong technical body which would give technical assistance to the Central Authority whenever necessary.

18.7.6. We recommend that the non-recurring and recurring costs of the Basin Authorities and their organisations be fully met by the Centre. This should include the Authorities' services free for items (i) to (ix) listed in para 18.7.4. The services for item (x) should be on payment by the requisitioning authority, of suitable charges including overheads.

We have not recommended any wing in the Basin Authority for item covered in (x) above as we expect requisitions for such services to be few and far between; these, the Authorities could handle with outside assistance.

18.7.7. We have suggested a Central Authority to coordinate the work of the River Basin Authorities. Till the constitution of such a Central Authority, the State Irrigation Ministers' Conference in which the Central Flood Control Board has now merged, may carry out the duties of the proposed Central Authority.

We have also suggested a strong technical body to assist the Central Authority whenever necessary. Till the constitution of such a body, it is suggested that the present organisation which is giving technical assistance to the State Irrigation Ministers' Conference may be strengthened with technical and administrative staff to enable it to discharge these additional functions.

18.7.8. As already stated "flood" master plans would form a part of the overall comprehensive plans for water resources development. For the present we have suggested constitution of River Basin Authorities to deal with inter-State rivers as far as only the flood problems are concerned; in due course they will handle complete water resources development for which they will have to be suitably strengthened.

The proposed River Basin Authorities will have to be clothed with sufficient powers to ensure that the policies and plans framed by them are actually implemented by the concerned States. For this purpose, they should be constituted as statutory authorities under the powers vested with Parliament under Entry 56 of List I of the Constitution. Unless this is done, the existing difficulties due to local interests overriding the overall regional or national interests will still remain, making the proposed River Basin Authorities ineffective.

18.8. Organisations in the States

18.8.1. The Ministers' Committee on Flood Control, 1964 had advised that, at least in the States with serious flood problems, Flood Control Departments should be organised under a Chief Engineer and appropriate lower staff. In para 18.3 we have explained the different types of set-ups in the States. By and large they seem to have functioned satisfactorily.

It will, therefore, be seen that the same type of authority may not be necessarily suitable in every State.

18.8.2. The plans prepared by the Basin Authorities will, in the usual course, have to be implemented by the States. We would, therefore, stress the necessity of having a strong implementing authority at the State level.

The Irrigation Departments in the States are to deal with comprehensive plans for water resources development, of which floods is a part. It is, therefore, our view that, in the overall interest, it is advantageous to have a unified irrigation and flood control department suitably strengthened as necessary in each State. Such a unified set-up is also advantageous for dealing with the important subjects of common interest detailed in para 18.8.3 post.

We would not, however, like to lay down a rigid pattern for all the States or even the flood-prone States. While indicating our preference for a unified department, we could leave it to the States to make the best judgment in this regard so as to suit their local conditions.

18.8.3. (a) There are some specialised subjects common to irrigation and floods which need individual attention. Here again it would be technically more suitable, as also being economical, to deal with them jointly.

Hydrology and flood forecasting

(i) Hydrology and hydrological observations are the basis of all projects dealing with water. They should be carried out on a continuing basis.

Flood forecasting is an allied subject, and could be added.

Planning investigations and project formulation

(ii) Planning and investigations are key elements in project formulation, and could form an independent unit. This unit should include a small economics cell for socio-economic evaluation.

Design, research and training

(iii) Designs are a very specialised item needing experience and continuity. A number of States have already set up Central Design Organisations, which have already proved their usefulness. These should be set up in other States also.

Research and training could form a part of this unit.

Monitoring and evaluation

(iv) We have noticed long delays in the completion of projects. These could sometimes be due to bottlenecks like supply of materials, acquisition of land, etc. It is desirable that the performance and progress of projects should be monitored and assessed from time to time. It is also necessary that quality control and construction schedules should be under constant watch. A monitoring cell would be useful in this regard.

(b) In States with a large number of works and adequate budgets, it may be possible to set up independent cells of the types mentioned above. Depending on local conditions, each could be handled by an officers usually not less than the status of a Superintending Engineer, and, where justified, by a Chief Engineer, with requisite lower formations. On the other hand, it is possible that in some of the States combinations could effect economy without sacrificing utility. As for example, hydrology could be combined with planning and investigations; similarly, monitoring and quality control could be placed under the Central Designs Organisation and so on. Such combinations are already working successfully in some of the States.

(c) While we recommend that the specialised cells mentioned above be set up, it is not possible for us to lay down a general rule applicable to every State. The States should implement these recommendations in the manner best suited to each one.

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ANNEXURE 18.1

No. FC.47 (3) /72
Government of India
(Bharat Sarkar)
MINISTRY OF IRRIGATION & POWER
(SINCHAI AND VIDYUT MANTRALAYA)

New Delhi, the 19th April 1972.

RESOLUTION

No. FC.47(3)72: In continuation of Ministry of Irrigation and Power Resolution No. FC.47 (2) / 72 dated the 18th April, 1972 constituting the Ganga Flood Control Board, the Government of India hereby constitute the Ganga Flood Control Commission.

2. The Commission will consist of the following wholetime officers:

(i) Chairman.
(ii) Member-Planning and Design.
(iii) Member-Coordination.

In addition the Chief Engineers in charge of flood control in the States of Bihar, Uttar Pradesh and West Bengal will be part-time Members of the Commission.

The Chairman of the Commission will be the Member-Secretary of the Ganga Flood Control Board.

3. The Commission will be entrusted with the following functions:—

(i) to prepare a comprehensive plan of flood control for the Ganga basin. The field investigations and collection of data for the purpose will be carried out by the State Governments as directed by the Ganga Flood Control Board;

(ii) to draw out a phased and coordinated programme of implementation of works included in the basin-wise plans;

(iii) to ensure the implementation of works to proper standards and their maintenance;

(iv) to prepare the annual programme of works and allocation of cost wherever required for the consideration of the Board;

(v) to operate the flood forecasting and warning system;

(vi) to assess the performance of flood control measures and

(vii) to make an assessment of the existing vent-ways under the road and rail bridges and to determine additional waterways to be provided for reducing the drainage congestion to reasonable limits.

4. The Commission will work within the broad framework of policy directions issued by the Ganga Flood Control Board and will work in close liaison with the Central Water and Power Commission and the State Flood Control Organisations.

5. The headquarters of the Commission will be at Patna.

6. The Commission will be assisted in all technical matters by a Technical Advisory Committee to be set up by the Government of India.

7. The Flood Control Works approved by the Board will normally be implemented by the State Governments concerned. If, however, it becomes necessary the Commission may arrange the execution of specific works.

Sd/-
(B. P. PATEL),
Secretary to the Govt. of India.

ORDER

Ordered that a copy of the Resolution be communicated to the State Governments of Bihar, Haryana, Madhya Pradesh, Orissa, Uttar Pradesh, Rajasthan and West Bengal, Ministries of Agriculture, Finance, Planning, Railways and Transport, Prime Ministers' Secretariat, Private and Military Secretary to the President and Comptroller and Auditor General of India.

Ordered also that the Resolution be published in the Gazette of India and the State Governments of Bihar, Haryana, Madhya Pradesh, Orissa, Uttar Pradesh, Rajasthan and West Bengal be requested to publish it in the State Gazettes for general information.

Sd/-
(B. P. PATEL),
Secretary to the Govt. of India.

To
The Manager
Government of India Press, Faridabad (Haryana).
Copy to: x x x
x x x

XIX LEGISLATION ON FLOOD CONTROL

19.1. Introduction

A comprehensive approach to the problem of flood control in India cannot ignore legislation needed for the prompt and satisfactory implementation of technically cleared flood control schemes and for ensuring reduction in the recurrent loss and damage to life and property caused by frequent floods. There are quite a few Indian laws covering some aspects of the subject and it is necessary to examine the laws with a view to remove deficiencies and, where necessary, to enact fresh legislation. In this context, the legislative competence of the Central Government as well as of the State Governments for undertaking flood control measures merits examination.

19.2. Legislative competence

The subject of flood control, unlike irrigation, does not figure as such in any of the three legislative lists included in the Constitution of India. However, two forms of flood control viz., 'Drainage and Embankments' are specifically mentioned in entry 17 of List II (State List), reproduced below:—

> "Water, that is to say, water supplies, irrigation and canals, drainage and embankments, water storage and water power subject to the provision of entry 56 of List I (Union List)." Entry 56 of List I (Union List) reads as follows:—
>
> "Regulation and development of inter-State rivers and river valleys to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest".

It may thus be seen that the primary responsibility for flood control lies with the States. A number of States have already enacted laws with provisions to deal with matters connected with flood control works. However, there exists a significant provision that the powers to be exercised are subject to entry 56 of Union List. It may be pointed out that entry 17 of List II (State List) quoted above does not cover land use involved in the administrative measures of dealing with reduction of flood losses viz., flood plain zoning.

When we consider the implementation of any flood control programme, it is necessary to acquire private land for execution of engineering structures. Since there is provision for "acquisition and requisitioning of property" in the Concurrent List under entry 42, both Centre and the States can enact laws for this purpose. The Land Acquisition Act of 1894 under which land could be acquired both by the Centre and the States is the basic Act in this regard. However, if legislation for reducing flood damages is to be resorted to by flood plain zoning, it involves restriction of land use and this power seems to be covered by entry 18 List II (State List) which provides "land that is to say, rights in and over land....". Also, since local conditions differ from area to area and, therefore, flood plain zoning is essentially a local problem, it needs to be dealt with by the State Government and the Centre does not come into the picture.

Notwithstanding the legislative power enjoyed by the Centre and the States as explained above, the Union Government can legislate on matters in the State List in two special situations viz., (1) under Article 249 the Council of States can declare by a Resolution supported by two-thirds of the Members present and voting that it is necessary or expedient in the national interest that Parliament should legislate on matters in the State List and specify in the Resolution, then Parliament can enact laws for the whole of the country or any specific part of the country with respect to that matter as long as that Resolution stand. The Resolution lapses after a year and can be renewed as many times as necessary, but not exceeding one year at a time. It may be seen that for one thing, the provision enables only temporary legislation, and for the other, the Rajya Sabha has to be satisfied that the problem of flood control has assumed such a magnitude that a national effort on an all-India level has become necessary. (2) Under Article 252, two or more States can empower the Parliament to make laws on matters included in the State List if the State legislatures of those States pass a Resolution to that effect. Such laws will apply to the States whose legislatures have already consented or which subsequently adopt the law. Once the law comes into force, none of the States can amend or repeal the same.

19.3. Existing legislation

Reference has already been made to the legislative powers of the Union Parliament and State legislatures. The main provisions of laws enacted by the Union and the State Governments on subjects connected with flood control are discussed hereunder.

19.4. Laws enacted by the Central Government

There are 4 Central legislations relevant to flood control.

19.4.1. *Inter-State River Disputes Act*, 1956

During the early years of British rule and until the enforcement of Government of India Act of 1919, irrigation works in India were under the control of the Government of India. In 1921, irrigation became a provincial, but a 'reserved' subject. According to this arrangement projects involving expenditure of over Rs. 50 lakhs and projects on an inter-State river had to be approved by the Secretary of State for India. With the passing of the Government of India Act, 1935, irrigation became a provincial subject and wholly within the legislative competence of the provinces. Nevertheless inter-State disputes were settled only by the Governor General. With the advent of Independence, the responsibility for irrigation continued to be with the States, but for settling inter-State river disputes, provision was made under Article 262 of the Union Constitution of 1950 for the Parliament to make laws for the adjudication of disputes. It reads as follows:—

> "1. 'Parliament may, by law provide for the adjudication of any dispute or complaint with respect to the use, distribution or control of the waters of or in any inter-State river or river valley.
>
> 2. Notwithstanding anything in this Constitution, Parliament may, by law, provide that neither the Supreme Court nor any other Court shall exercise jurisdiction in respect of any such dispute or complaint as is referred to in Clause 1."

By virtue of powers vested in Parliament by Article 262, it enacted the Inter-State Water Disputes Act, 1956. Section 3 of the Act lays down that if it appears to the Government of any State that a water dispute with the Government of another State has arisen or is likely to arise, by reason of the fact that the interests of the State or of any inhabitants thereof in the waters of an inter-State river or a river valley have been or are likely to be affected prejudicially by:—

(a) any executive action or legislation taken or passed or proposed to be taken or passed by the other States; or

(b) the failure of the other State or any authority therein to exercise any of their powers with respect to the use, distribution or control of such waters; or

(c) the failure of the other State to implement the terms of any agreement relating to the use, distribution or control of such waters,

it may request the Central Government to refer the dispute to a tribunal for adjudication.

Section 4 of the Act says that "when any request under Section 3 is received from the State Government in respect of any water dispute and the Central Government is of the opinion that the water dispute cannot be settled by negotiations, the Central Government shall, by notification in the official fiazette, constitute a water dispute tribunal for the adjudication of water dispute".

19.4.2. *Implementation of the Inter-State River Disputes Act*, 1956

The grounds for inter-State river disputes that have arisen so far centre round one or a combination of the following:—

(1) the sharing of waters of an inter-State river, *e.g.*, The Krishna, the Godavari, the Narmada.

(2) the apportionment of costs and benefits of a joint venture of two or more States, *e.g.*, the Tungabhadra dam.

(3) the interpretation of an agreement or of the terms of an award, *e.g.* The Kaveri dispute between Karnataka and Tamil Nadu regarding the 1924 agreement.

Though there have been many disputes on account of the ever increasing demands for water and power in different areas of the country, all the disputes have not been referred to adjudication. Most of them have been settled by negotiations with the active and beneficial participation of the Union Government. So far, only three tribunals have been set up to adjudicate in inter-State disputes, viz., those relating to the Krishna waters, the Godavari waters and the Narmada waters. The awards on the Krishna and the Narmada water disputes have already been given and are in the process of implementation by the States concerned.

The Act no doubt provides for reference of a dispute to the tribunal, but it takes a long period for a tribunal to come to a final decision. Therefore, it has been recognised by most people that the best method of settling a dispute is by mutual agreement.

19.4.3. *The River Boards Act* of 1956

Under entry 56 of List I (Union List), Parliament has enacted the River Boards Act of 1956 which authorises the Union Government to, "establish a River Board for advising the Governments interested in relation to such matters concerning the regulation or development of an inter-State river or river valley or any specific part thereof and for performing such other functions as may be specified in the notifications". The Act also provides that a Board could be established for one inter-State river or river valley or for a group of inter-State rivers or river valleys in consultation with the State Governments interested. The Act created a machinery for investigating the water potential of a river basin, for collecting requisite data, and, for advising the State Governments concerned on the best means to develop the water resources of the basin as a whole. The Act does not clothe the Central Government with any powers to develop or regulate the flows of inter-State rivers or to control the activities of the State Governments in respect of these waters; nor does it lay down any policy or guidelines regarding the utilisation or control of these waters. The Boards were empowered to apportion the cost of development and to monitor the progress of work. When a River Board failed to secure agreement on any aspect of the advice tendered by it or where any of the concerned Governments refused or neglected to undertake any measures in pursuance of such advice or where disputes rose between two or more Governments with respect to any measures undertaken by a Government in pursuance of advice tendered by the Board or with regard to the sharing of benefits or financial liabilities arising out of such advice, the dispute could be referred to arbitration by any of the interested Governments. The Arbitrator was to be appointed by the Chief Justice of India from amongst serving or retired judges of the Supreme Court or High Courts. The Arbitrator was empowered to appoint two or more persons as Assessors to assist him. The Arbitrator's decision was final and binding on the parties.

19.4.4. *Implementation of the River Boards Act of 1956*

The Act was passed in 1956 and came into force on the 15th May 1957. The question of providing finances for the functioning of the Boards and the scope of the work *vis-a-vis* the existing agencies remained under discussions till 1961. Then, it was decided to begin with the setting up of River Boards for the rivers Narmada, Tapi, Mahi, Krishna, Godavari, Mahanadi, Ravi, Beas and Sutlej, Kaveri and Ajai and Bhagirathi. As per Section 4(i) of the Act, Notification for the setting up of a River Board should be issued only after consultation with the interested State Governments with respect to the proposal to establish the Board, the persons to be appointed as Members thereof, and the functions of the Board may be empowered to perform. However, most of the States did not agree to the setting up of the Boards and, therefore, no River Board has been set up so far.

19.4.5. *Damodar Valley Corporation Act,* 1948

This is a pre-Constitution Act, enacted by the Central Government in 1948 in pursuance of Section 103 of the Government of India Act, 1935. The Act provides for the establishment and regulation of a corporation for the development of the Damodar Valley in the States of Bihar and West Bengal. The Act lays down the composition and functions of the Corporation and details the powers in respect of allocation of capital, finance, audit and accounts, acquisition of lands etc.

The functions of the Corporation are as below:

(a) the promotion and operation of schemes for irrigation, water supply and drainage;

(b) the promotion and operation of schemes for the generation, transmission, and distribution of electrical energy, both hydro-electric and thermal;

(c) the promotion & operation of schemes for flood control in the Damodar river and its tributaries and the channels, if any, excavated by the Corporation in connection with the scheme and for the improvement of the flow conditions in the Hooghly river;

(d) the promotion and control of navigation in the Damodar river and its tributaries and channels, if any;

(e) the promotion of afforestation and control of soil erosion in the Damodar Valley; and

(f) the promotion of public health and the agricultural, industrial and economic well being in the Damodar Valley and its area of operation.

19.4.6. *Implementation of D.V.C. Act*

The Damodar Valley Corporation was established in July 1948. Out of 7 dams originally planned for the purpose of irrigation, flood control and power, it has constructed 4 dams *viz.*, Maithon, Panchet, Konar and Tilaiya. It has also constructed a Barrage at Durgapur to feed the network of irrigation canals. It has also set up a number of thermal power stations. The Dams have moderated the floods to the extent these 7 dams were designed for. The power generated by its power houses and assured irrigation have helped in the rapid industrialisation of the area.

The Corporation has not been able to discharge all the functions envisaged in the Act due to the fact that the valley covers two States. Conflict of interest of the States has been largely responsible for only the partial realisation of the benefits envisaged in the Act.

19.4.7. (*a*) *The Land Acquisition Act,* 1894.

This is a Central legislation empowering the Central and State Governments to acquire land for any public purpose. The proceedings start with a Notification under Section 4(i); Section 4(ii) authorises the Government to enter upon and survey the land. While this survey is under progress, it is open to any person interested, to raise objections before the Collector within 30 days after issue of the said Notification. The Collector is authorised to hear the objections and after hearing, submit the case to the Government for a decision. When the Government is satisfied after considering the Report of the Collector, a declaration is made under section 6 that a particular land is required for a public purpose and this is published in the official gazette. Under Section 7, the Government directs the Collector to make an order for the acquisition of land. The procedure before the Collector for the award of compensation is detailed under sections 8 to 15. Section 16 authorises the Collector to take possession after he has made the award under Section 11 and after that the land vests absolutely in the Government free from all encumbrances. Section 17 provides for special powers in cases of urgency. Section 18 to 28 provides for the procedure for a reference to court if a person is not satisfied with the award of the Collector. Section 23 enumerates the factors for determining the compensation. Of importance is the provision for the award of the market value of the land on the date of publication of Notification under Section 4(i) plus 15 per cent solatium in addition to the market value. Section 24 lists those matters which are to be left out in determining the compensation.

19.4.8. *Implementation of the Land Acquisition Act*, 1894.

This law has been operative for all these years. But still a major problem in the execution of flood control programme has been the delay in land acquisition. There is delay at many stages of the proceedings. To overcome this difficulty, some of the States like Maharashtra, Gujarat have adopted the practice of making an advance payment of 80 per cent of the likely amount of compensation, subject to certain conditions.

As discussed above, there is provision under section 17(2) for acquisition of lands in case of emergent situations. However, these powers can be exercised only in case of Railway administration and is not applicable for flood control works. Emergent situation may arise for taking up flood protection works also. Therefore, Bihar State enacted Land Acquisition (Bihar) Amendment Act, wherein similar provision as existing under 17(2) was made for emergent flood control works too. Some States enacted laws providing less compensation than what is ordinarily payable under the Land Acquisition Act of 1894, but these were struck down by the Supreme Court.

19.4.9 The above position would go to show that the State Governments have wide powers to enact flood control laws. However, in the case of Inter-State rivers, Central Government can assume and exercise powers *vide* Entry 56 and 42 of the Union List of the Constitution, and can enact laws for the purpose of regulation of inter-State rivers especially from the point of view of flood control.

Lack of a co-ordinated and national approach has often resulted in *ad hoc* measures. There are instances where the flood problem in one State has got transferred to the neighbouring State on account of the measures taken by the first State. For example, construction of embankments and anti-erosion measures on the Yamuna by Uttar Pradesh and Haryana, and drainage schemes in Haryana and Delhi have led to the worsening of the flood situation in the neighbouring State. This state of affairs can be remedied only if effective legislation for regulation and control of floods is undertaken.

We, therefore, recommend that the Central Government should assume the powers conferred on it by the Constitution for the regulation and development of inter-State rivers by enacting suitable legislation.

We also suggest that the State Governments look into the problems of delays in land acquisition and examine if the process can be expedited by issue of administrative orders laying down a suitable time schedule for disposal of such cases. We recommend that all the State Governments should examine the possibility of adopting the practice of advance payment of 80 per cent of compensation as is being done by the States of Maharashtra, Gujarat etc. This advance payment will induce the owners of the land to permit construction of flood control works on their lands pending final award of compensation.

We also recommend that other States may also follow the example of Bihar in making suitable amendment of Section 17 (2) of Land Acquisition Act so as to make it applicable to flood control works in emergent situations.

19.5. Laws enacted by State Governments

In India, there is a multiplicity of laws relating to irrigation and water rights but only two that deal exclusively with flood control. Some of the former touch one or the other aspect of flood control. These Acts are both pre and post Constitution laws. In the case of a few States, there are more than one law dealing with the subject of floods. Many of the laws were enacted before the reorganisation of States and creation of new States. Some of the important ones are listed here.

19.5.1. *The Assam Embankment and Drainage Act*, 1954.

This, a flood control Act, provides for construction, maintenance, management, removal and control of embankments as well as for drainage of lands in the State of Assam. The Act empowers the embankment officer to initiate schemes for construction of embankments for preventing floods and for removal or alteration of any embankment or any construction which in his opinion would endanger the safety of any town or would interfere with the flood drainage of any tract of land. The State Government can also levy betterment cess on lands benefited by the execution of a scheme towards realising the initial cost of the scheme in full or in part and for its maintenance. The rate should not exceed 6 per cent per annum on the first cost of the works along with the estimated cost of annual maintenance. The levy can be recovered in the same manner as land revenue.

Actions like raising or cutting off trees, grass or shrub on any embankment or drain or taking vehicles over embankments or drains, damaging or obstructing the function of any drain or embankment are punishable with imprisonment extending up to 6 months or fine up to Rs. 2000 or both.

19.5.2. *The Andhra Pradesh Irrigation (Levy of Betterment Constitution) Act,* 1955.

This Act provides for the levy of betterment contribution from the beneficiaries and is leviable from owners of land which is benefited by the execution of any flood control work costing over Rs. 1 lakh. The contribution is to be levied after the expiry of three years from the date of completion of the work and it shall not exceed one half of the increase in the value of the land on account of the work.

19.5.3. *The Bengal Embankment Act,* 1882

This Act applies to the State of West Bengal, Bihar and parts of Orissa. It provides for the construction, maintenance and management of embankments. The Act also provides for recovery of cost of work from the beneficiaries after apportionment of cost of works. In case of failure to pay, the dues can be recovered as arrears of land revenue.

19.5.4. *The Bengal Irrigation Act,* 1876

Under section 43 of this act, a scheme for protection of lands from floods can also be drawn up and executed whenever the State Government is of the opinion that protection from floods or other accumulations of water or erosion of a river is required.

The Act prohibits obstructions of any river or stream or natural drainage course. It empowers the authorised officer to order removal of such obstruction and in case of non compliance, remove the same himself.

19.5.5. *The Bihar Public Irrigation and Drainage Act,* 1947.

This Act also provides for taking up schemes for flood control. Any land or interest in the land needed for the sanctioned works is deemed to be needed for a public purpose within the meaning of Land Acquisition Act 1894.

The Act provides for compensation to be assessed on the market value of the land with reference to the date on which Government publishes the scheme and not on the date of initial notification for acquisition under sec. 4(1) of Land Acquisition Act, 1894. The Act also provides for compensation for consequential damages.

The State Government may recover the cost of the work together with interest at any rate between 4 to 5 per cent per annum in 10 or more instalments. The cost of maintenance can also be recovered instalments from these persons. Instead of recovering costs as mentioned above, the State Government may alternatively levy a cess for recovery of interest at the rate of 4 to 5 per cent per annum on the expenditure incurred on the work and its annual cost of maintenance. This cess can be charged annually or at shorter intervals.

19.5.6. *The Bihar Irrigation and Flood Protection (Betterment Contribution) Act,* 1959

Whereas, the Bihar Public Irrigation and Drainage Works Act, 1947 discussed earlier provides for recovery of cost of flood control works or a cess on the capital cost plus maintenance and their recovery, this act provides for the levy of betterment contributions and their recovery. The betterment contribution recovered is to be earmarked for servicing the debt raised for flood control works or on construction, improvements or major repairs of such works.

The Act makes a distinction between flood protection works on lands in rural areas and urban areas. No contribution is leviable in rural areas if the cost of such works is less than Rs. 5 lakhs. Rates of contribution have been specified separately for urban and non-urban areas.

The Act indemnifies the State Government against claims for compensation or for the refund of betterment contribution on account of the loss by temporary failure of flood protection works or by any repairs, alterations or additions to such work. It also bars suits against officers for any act done or intended to be done in good faith under the Act and the rules.

19.5.7. *The Bombay Irrigation Act,* 1879

The Act covered the States of Maharashtra and Gujarat. Maharashtra has enacted the Maharashtra Irrigation Act, 1976. This act provides for flood control measures as indicated in the definitions of 'drainage work' and 'flood embankment'.

It provides for prohibition of encroachments into natural drainage channels and their removal if deemed necessary.

The Act has provisions for obtaining compulsory labour for emergencies arising from floods n payment at the highest prevalent rates in he neighbourhood.

9.5.8. *Jammu and Kashmir—The Canal and Drainage Act* 1906

The purpose of this law is to regulate the use nd control of water in Jammu and Kashmir. But, it also deals with 'drainage work' which is efined as including escape channels from anals, dams and weirs as also embankments, luices, groynes and other works for the protection of lands from flood and flood erosion. It lso provides for prohibition of encroachments nto natural drainages and removal of structures, f necessary. This Act also provides for compulsory labour, on payment, for emergencies rising from floods. The Act makes provision or recovery of charges from owners of lands enefited by the scheme.

9.5.9. *The Madhya Pradesh Irrigation Act*, 1931

The only aspect of flood control dealt with n the Act is the power of the State Government to prohibit by notification, stating the pecific limits, obstruction of any river, stream r drainage channel, when in the opinion of the Government such obstruction will cause injury o public health or public convenience.

19.5.10. *The Madras River conservancy Act* 1884

This Act applies to the States of Tamilnadu, Karnataka, Kerala and Andhra Pradesh.

It prohibits unauthorised actions of private ndividuals in abstructing from the flow of rivers. The Act empowers the State Governments to survey the rivers and lay down limits which define the river bed and within which, no planting or other work, which obstructs the current of the river is permitted. The conservator of rivers is empowered to prevent interference with the course of river, for which purpose, the State Government has to declare by a gazette notification, that conservancy of any specified river is required.

The land in river bed which was not cultivated for two years previous to the date on which the Act is applied to the river, cannot be cultivated without the written permission of the conservator of rivers.

The conservator of rivers can also, with the previous sanction of the collector, prohibit the cultivation of any cultivated land in the river bed, if he thinks that the cultivation will tend to obstruct the flow or divert the course of the river.

The Act also empowers the conservator of rivers to ask the owner or occupier of any land within any river bed to remove any groynes, buildings, constructions, plantations, grasses or other things upon such lands, which the conservator may deem to be an obstruction to the course of the stream of such river. Violation of these provisions is punishable under the Act.

The conservator of rivers is empowered to undertake any act designed to prevent erosion, breach of embankment or flooding over them, encroachment by the stream or danger to life or properties.

All damages arising out of prohibition of new cultivation on lands in beds of notified rivers, prohibition of cultivation on cultivated lands in river beds, removal of constructions, plantations or any act to conserve the river are to be compensated. However, the Act does not specify the method of calculating the amount of compensation to be paid.

19.5.11. *The Madras Irrigation (Levy of Betterment Contribution) Act*, 1955

This Act is similar to the Bihar and Andhra Acts for betterment levy and applies to the State of Tamilnadu.

This Act empowers the State Government to levy betterment contribution from the landholders of all lands which are benefited by the execution of any 'Notified work' meant for the protection of lands from floods or from erosion, at the rates specified in the schedule. However, betterment levy is leviable only if the cost of the work exceeds Rs. 1,50,000.

19.5.12. *Manipur Flood Plain Zoning Act*, 1978

This Act has been enacted by Manipur State to regulate the developmental activity in the flood plains.

The State Government is empowered to notify and demarcate the flood plain area after proper survey, and prohibit or restrict the use of land therein as specified under the rules.

The Act is to be administered by a specially constituted Flood Zoning Authority. This authority will carry out surveys of flood plains of the rivers and determine the nature and extent of flood plains of the rivers, and classify the land with reference to relative risk and permitted land use and publish them for reference.

Where permission to undertake any activity in the flood plain has been refused to any person or where as a result of the prohibition/restriction, such person suffers any damage, he is entitled to the payment of conpensation not exceeding the difference between the value of land as determined under Section 23 or Section 24 of Land Acquisition Act, 1894 and the value which it would have fetched, had the permission for carrying on the activity been granted, or prohibition/restriction not been imposed.

The Flood Zoning Authority has been empowered to direct the owner/occupier of land to remove any unauthorised obstruction and in case of failure to comply, get it removed at the cost of the defaulting party.

Prevention of 'Flood Zoning Authority' from discharging any act is an offence under Section 186 of the I.P.C. The Government, any authority or any person exercising any power or performing any duty under the Act is protected against any suit, prosecution or legal proceedings for any of the actions taken in good faith in pursuance of the Act.

All fines imposed are to be treated as arrears of land revenue and recovered accordingly.

19.5.13. *The Mysore Irrigation Act*, 1965, *Karnataka Irrigation Act*, 1967

Under Section 2 (h) of this act, 'irrigation work' includes all 'drainage works' and 'flood embankments'.

The Act empowers the State Government to frame schemes for construction works for drainage as also for protection from floods, inundation or from erosion by a river.

The Act empowers the State Government to prohibit obstruction of rivers when in its opinion such obstruction is likely to cause injury to public health, public convenience, flood embankment or drainage work. Such prohibition has to be duly notified in the gazette, stating the limits up to which it extends.

There are provisions for obtaining compulsory labour in emergencies in connection with flood control works.

The Act also provides for the levy of maintenance cess at Rs. 4/- per acre per annum on the lands in the area benefited by any flood control works and is recoverable as arrears of land revenue.

19.5.14. *The Northern India Canal and Drainage Act*, 1878

This Act extends to Uttar Pradesh, Punjab, Haryana and Delhi and regulates irrigation, navigation and drainage works on all rivers, streams and water bodies in the above States and the Union Territory of Delhi. The Act applies to flood control by virtue of the definition of the term 'drainage work' which includes escape channels from canals, dams and weirs as also embankments, sluices groynes and other works for the protection of land from flood or from erosion.

The Act empowers the State Government to prohibit or order the removal or modification of any obstruction within the specified limits of any river by a notification in the gazette, and, in the event of non-compliance, to remove the obstruction at the cost of the defaulting party.

The State Government can fix an annual rate within the limits specified below, which may be charged from the beneficiaries of a scheme:

(i) six per cent per annum on the first cos of said works, adding thereto the estimated yearly cost of maintenance and deducting any estimated income.

(ii) in case of agricultural land, the sum which, under the rules in force for the assessment of land revenue, might be assessed on such land on account of the increase in annual value or produce thereof, caused by drainage work.

This rate is recoverable as arrear of land revenue. This Act also provides for requisition of labour from the persons whose lands are benefited by the work at rates exceeding the highest prevailing rates in the neighbourhood.

19.5.15. *The Orissa Public Embankment Construction and Improvement Act*, 1951

This Act provides for construction and improvement of public embankments for the prevention of floods in Orissa. The term embankment has been so defined as to include all types of flood control structures.

There is no provision in the Act for acquisition of land survey work, or payment of compensation. It provides for the recovery of cost incurred in construction or improvement of any public embankment in part or full from the beneficiaries, which can be recovered as arrears of land revenue.

19.5.16 *The Orissa Hydro-Electric Projects and Flood Control Works (Survey) Act*, 1961

The Orissa Public Embankment Construction and Improvement Act 1951 deals with public embankments alone whereas the main purpose of this Act is to provide for survey and investigation of suitability of lands needed for hydro-electric projects and flood control works in the state of Orissa.

The Act provides for payment of compensation for damages sustained by an individual during the course of survey. The compensation amount, if disputed, is to be decided by the collector, and a civil suit is barred by the Act.

19.5.17 *The Orissa Irrigation Act*, 1959

It provides for one aspect of flood control namely the power of the State Government to prohibit obstruction of any notified river, when in the opinion of the Government such obstruction will cause injury to any land, public health or public convenience. The State Government is empowered to ask for removal of an unauthoised structure|obstruction. In the event of on-compliance within the specified time limit, t can remove or alter the same and recover the ost from the defaulting party, as arrears of and revenue.

The Act also empowers the authorised officer o requisition compulsory labour to execute vork in case of an emergency.

The Act empowers the State Government to lassify all irrigation works (which include rainage works) for the levy of water cess for the maintenance and repairs of such works.

19.5.18 *The Rajasthan Irrigation and Drainage Act* 1954

Part VI of the Act deals with drainage. The term 'drainage' is defined to be inclusive of escape channels from a canal, dams and weirs as also embankments, sluices, groynes and other works for the protection of land from flood or erosion.

The Act empowers the State Government to prohibit, by a gazette notification, the creation of an obstruction in any river, stream or drainage channel, in the area notified, if it apprehends any injury to any land or public health or public convenience. If the persons concerned do not remove the obstruction, the same can be got removed at the cost of defaulting parties.

The State Government can levy an annual rate in respect of a scheme and charge it on the owners of all lands which are determined to be chargeable.

In case of an emergency, there is provision for compulsory requisition of labour from the beneficiaries.

19.5.19 *The Travancore Cochin Irrigation Act,* 1958

This Act which is applicable to the State of Kerala has been enacted essentially for the construction, repairs and maintenance of irrigation works and levy of betterment contribution and water cess. "Irrigation works" include all drainage works like canals, escape channel from a canal, reservoirs, or tanks, dams, sluices, embankments, weirs, groynes and other works for the protection or benefit of agricultural lands or for reclamation of lands; the Act is applicable to flood control works also.

19.5.20. *The Uttar Pradesh Flood Emergency Powers Evacuation and Requisition Act,* 1951

The Act provides for only one aspect of flood control namely evacuation of areas threatened or affected by floods. The Act empowers the District Magistrate to order compulsory evacuation of people and property from areas threatened by floods. The order can specify the route and time by which the persons are to be removed and the place to which they are to proceed. In order to accommodate the people so compulsorily evacuated, the District Magistrate is empowered to take possession of any premises other than those used for religious purposes or a private dwelling house.

The District Magistrate has also powers to requisition boats from private parties and impound them in case of non-compliance. His authorised officer can enter any premises/boat to assess whether the house or boat is fit for use. However, the power to take possession of premises or requisition boats is subject to payment of compensation to affected parties.

By an amendment in 1964 the District Magistrate is empowered to divert flood flows or remove any obstruction to the river flow so as to prevent imminent danger to life or serious damage to property.

19.6. Appraisal of the State Acts

A statement showing the position of available legislation in respect of flood control in the country is enclosed as Annexure 19(i). The more important provisions of the different State Acts detailed in the foregoing paragraphs would shows that none of the Acts has adequate provisions to comprehensively deal with all aspects of flood control. Emphasis has been on one or more aspects and hence an appraisal of the State Acts with reference to important aspects of flood control has been attempted.

19.6.1 *Preparation of schemes for flood control.*

The Assam and Bihar Acts provide only for preparation of schemes for flood control whereas Bombay, Bengal, Jammu & Kashmir, Punjab, Uttar Pradesh, Haryana, Delhi, Rajasthan, Orissa and Mysore Acts contain provisions for prevention of obstruction to river flow as well as preparation of schemes for flood control. In the case of the former States, the Acts provide full powers to the State Governments subject to procedural safeguards for the affected parties to undertake the construction of flood protection works. In case of an emergency, the procedural safeguards such as notice and enquiry can be dispensed with. The Acts provide for compensation for losses suffered as a result of survey work and execution of schemes. In some of the Acts of latter group, there is no provision for procedural safeguards for the aggrieved parties before a scheme for flood control is approved by the State Government, e.g. Bombay. There is, however, a safeguard in respect of entry on land and buildings as adequate notice has to be given to the affected parties before such entry.

19.6.2 *Acquisition of land or property*

Most of the Acts discussed above do not provide for acquisition of land or property in connection with the execution of flood control works. In some Acts, a reference has been made to the application of Land Acquisition Act of 1894 for both acquisition as well as payment of compensation towards damages incurred in connection with survey and execution of flood control schemes. Some States like Assam, Bihar, Karnataka and West Bengal have enacted separate legislation for acquisition of land and property on the basis of the 1894 Act.

19.6.3 *Prevention of obstruction to river flow and removal/modification in rivers and drainage channels*

Almost all States have legislation which prevents obstruction to flow in rivers and drainage channels. The Madhya Pradesh Act provides only for prevention of obstruction to river flow and no other flood control aspect. Most of these Acts provide for safeguards for the parties concerned, as a notice is to be given initially for the removal or modification failing which the work will be got done at the cost of the defaulting party. In some Acts, provision has also been made for payment of compensation for damages that may be suffered by the private land owners on account of such removal or modification of obstruction.

19.6.4. *Flood Plain Zoning*

Only one State, namely, Manipur has passed an Act on flood plain zoning. It is fairly comprehensive so far as flood plain zoning is concerned, but does not deal with any other aspect of flood control. The Madras Rivers Conservancy Act, 1884 which applies to the southern States of Tamil Nadu, Andhra Pradesh, Karnataka and Kerala prohibits obstructions within specified widths of notified rivers. This Act also does not provide for preparation of schemes for flood control and other important aspects.

19.6.5. *Compulsory Evacuation of people and property from areas threatened or affected by floods*

Only the Uttar Pradesh Flood Emergency Powers (Evacuation and Requisition) Act, 1951 has provision for compulsory evacuation of people and property threatened by floods. This is an important aspect which is missing from enactments of other States.

19.6.6 *Contribution by beneficiaries*

All the States except Bombay have legislations empowering them to levy an annual rate on lands benefited by the execution of flood control measures. The object of this provision appears to be that the beneficiaries should contribute to the State exechequer towards the cost, upkeep and maintenance of flood control works. Some of the Acts do not lay down the procedure for arriving at the levy though some Acts have clearly specified the method of fixing the levy. It is presumed that the rules to be issued by tl State Government would prescribe the procedu for the levy. The Acts prevalent in Assan Bihar, Andhra Pradesh and Kerala contain de tailed provisions for the levy and recovery (betterment contribution from the landholde benefited by flood control works. They als provide for hearing of objections from th affected parties. It would be better if the Ac itself contains a procedure for the levy rathe than leave it to the Government to make rule for the purpose.

19.6.7 *Requisition of labour*

Some of the Acts in force in Rajasthan, Maha rashtra, Gujarat, Karnataka, Orissa, Uttar Pra desh, Punjab and Haryana provide for requisi tion of compulsory labour by the State for floo control works in case of an urgency. They als contain certain safeguards. A requisition ha to be placed in writing and it has to include th specific number of labour required, the natur and locality of the work to be done, the perioc for which it is required and the day on whicl the labour is needed. It is also obligatory fo a copy of the requisition to be sent to the Stat Government for information. Another impor tant safeguard for the labour is that the wage shall always exceed the highest rates prevalen in the neighbourhood and has to be double th rate for night work.

19.6.8. *Disaster prevention and preparedness*

None of the States has comprehensive legislation to deal with all aspects of disaster prevention and preparedness, though provision for requisition of boats exists in a few Acts.

19.6.9 *Special provisions in the State Acts*

The Bihar Act provides for betterment contribution at different scales for rural and urban lands for the levy of betterment contribution. Similarly, the Bihar Act provides for indemnifying the State Government against claims for compensation or refund of betterment contribution due to loss arising from reasons beyond the control of the State Government. The Bihar Act goes further to provide that betterment contribution be set apart for the specific purpose of serving debts incurred for flood protection works or construction, improvement or major repairs of such works.

19.7. Acts on Flood Control in other countries

19.7.1 *United States of America*

In the United States, federal interest in navigation preceded federal interest in flood control. Federal concern in matters of flood control may be traced back to 1850 but only as part of the federal navigation programme. Flood control started gaining separate recognition as a result of Sacramento floods in California in 1917, and the Lower Mississippi Flood of 1927. The first comprehensive flood control Act was passed in 1936 and is known as Flood Control Act of 1936 (Public Law 74-738). This Act authorised the Federal Government to assume the responsibility for flood protection as a national concern. This Act was followed by a number of enactments which authorised various types of investigations and studies as well as construction of many additional projects for flood control. This Act underwent major modifications in 1944, when another enactment was passed. This Act established the basis for coordinated and comprehensive development of water resources of a river basin, revising the previous policy of a single purpose concept. The other majod provision was that major drainage improvement projects may be classed as flood control projects. If the project was constructed wholly or in part with federal funds, the regulation operation policy was to be laid down by the Secretary to the Army.

(ii) *Watershed Protection and Flood Prevention Act,* 1954

This Act authorised the carrying out of plans for reduction of flood damages along streams draining less than 101,000 hectares. These plans were to encompass both engineering works and land treatment measures and pertain almost entirely to the planning and construction of small headwater reservoirs, and other engineering works having no more than 6.2 million cubic meters capacity. This law underwent amendment in 1965, according to which, to 'Soil Conservation' service was required to provide protection to upstream agricultural plains and that Corps of Engineerings to provide protection for downstream agricultural flood plains. The limit of storage reservoirs covered therein was raised to 14.8 millions m^3.

(iii) *Flood Control Act,* 1960

This Act authorised the Secretary to the Army through the Chief of Engineers to compile and disseminate information on floods and flood damages including identification of areas subjected to inundation by floods and general criteria for guidance in the use of flood plain areas and to provide engineering advice to local interests for their use in planning against flood hazards.

(iv) *National Flood Insurance Act,* 1968

The Flood Insurance Programme was established in the year 1968 when the Congress passed the National Flood Insurance Act of 1968. Broadened and modified since then, the programme is administered by the Federal Insurance Administration within the U.S. Department of Housing & Urban Development. The insurance is for buildings and their contents only. Agricultural crops and land etc. are not covered under the programme. It is worked jointly by the US Government and a consortium of private insurance companies and is subsidised to the extent of 90 per cent by the Federal Government. The programme has two goals (i) to compensate the flood victims for their monetary losses in the short-term and (ii) to encourage flood plain zoning for the longer terms reduction of flood damages.

Amendments to the Act made in 1973 have changed the entire concept of the original programme, by making it virtually compulsory rather than voluntary. The Act provides that in communities which have identified flood hazards, property owners eligible for flood insurance, must purchase such insurance or lose eligibility for federal assistance for construction and acquisition in the identified flood plain. This includes bank loans and mortgage insurance that are in any way regulated or insured by the Federal Government. Flood insurance is made available only when a community adopts land use regulation standards prescribed by the Federal Insurance Administration. A community will not be entitled to receive flood disaster assistance if it does not participate in the insurance programme.

(v) *Flood Plan zoning*

Flood plain zoning is implemented at the local level by the States and local authorities. The Federal Government prepared a Standard Zoning Act in 1926 to serve as a model for the States to enact zoning legislation. Several States have enacted legislation on this model.

19.7.2 *Austria*

In Austria, there are two laws which create the legal basis for carrying out appropriate flood control measures in accordance with the specific regional requirements taking into account all factors influencing the concerned areas. The first law is the law on Water Rights. This Law regulates questions arising in connection with rivers and drainages and their uses, including flood control and cultivation of flooded areas, and provides respective legal orders. Management of flood-prone areas is dealt with under Article 38.

The second Law is called the Law on the Promotion of the Construction of Water Works. This Law distinguishes 'federal rivers' and 'competing water courses' and provides measures for the promotion of the construction of hydraulic works. This law lays down that the responsibility for financing water works at Federal rivers rests entirely with the Republic of Austria. But those works constructed in the competing rivers are to be promoted by the Federal Republic in conjunction with the respective Federal Provinces.

Federal rivers are financed by the Republic of Austria but beneficiaries may be called upon to pay appropriate contributions to the costs. As far as competing water courses are concerned, the costs are shared by the Austrian Republic, Federal provinces concerned and the local interested parties in accordance with fixed rate of contribution as provided by the law on the Promotion of Water Works. The users of water courses often join to form cooperatives and associations for the construction and maintenance of the flood control works within the framework of the respective regulations provided by the law on Water Rights.

19.7.3. *Canada*

The ownership of natural resources is primarily provincial except for lands such as national parks owned by the Federal Government. The Provinces may organise development licence uses regulate flows and levy fees. They also have authority to legislate on such matters as flood control, domestic and industrial water supply, power development, irrigation, reclamation, recreation and pollution abatement. The Federal Government on the other hand has legislative powers over navigation, fisheries, inter-provincial and international undertakings. In addition, the Federal Government has certain general powers which can influence water development both directly and indirectly. In the Province of Ontario, the Provincial Conservation Authorities Act provides for setting up of conservation authorities which are really corporate autonomous bodies responsible for enunciation, construction and to some extent operation and maintenance of flood control projects. The working unit of an authority is formed around a water shed. This Act is designed to encourage local interests and involve them in responsibility for management. The more recent development in Canada is not to consider mitigation of flood by itself but as a component of the overall comprehensive basin plan. The Federal Government, for example, proposes to consider overall national interest as a criterion in financing future projects and programmes.

It is also of interest to learn that great emphasis is now being put on non-structural alternatives to alleviate flood problems. A legislation recently enacted in the Province of Manitoba provides for focible evacuation of residents, if need be, in an impending flood emergency.

19.7.4. *France*

In May 1858, a law was enacted to protect towns and regulate the construction of dykes in submersible areas of the valleys. In 1935, this Act was abrogated by a decree and a law was passed exending the 1858 law to all works such as dykes, fills, deposits of obstructive materials, enclosures, plantations, constructions, etc. susceptible of obstructing the free flow of waters or restricting the flood plain in a harmful manner. This regulation, still in force, is applicable to inundable parts of certain rivers.

As regards construction of structures, the responsibility in the matter of flood protection works is fixed by the 1939 Decree which provides for the execution of these works under the control of the Ministry of Supply & Housing. The basic principle is that flood protection should be the main responsibility of the concerned landlords, the local collectives, etc., which can, however be substituted by the interested parties. The State may sanction subsidies for the execution of works.

As regards the management of the flood plain, a Decree of 1937 amended by another Decree in 1962, determines general administrative measures to be taken for implementation of the Decree of Law of 1935. In practice, the submersible areas are classified in two zones according to high flow velocity (zone A) and low flow velocity (Zone B). The decrees of the State Council approve for each department, after study of the limits, the Zones A & B and the technical provisions as applicable to these zones.

Normal or deferred maintenance of Crown rivers is carried out by the State, owner of the works. However, funds may be provided by the collectives or individuals, specially interested in these works. Maintenance of the non-Crown rivers do not receive State aid and will have to be carried out by the riparian landowners who are in charge of these maintenance works or other individuals or collectives. Protection and flood control works like dams, reservoirs, dykes, channel improvement etc., are, in principle, financed by the beneficiaries. The owners of the works may, however, receive aid from the State on completion of the works. If it involves the protection of residential urban areas or means of communications or evacuation of inundated areas, a subsidy may be granted by the Ministry of Supply & Housing up to a maximum of 30 per cent. If it is for the protection of rural area or farm areas, a grant-in-aid may be accorded by the Ministry of Agriculture and its rate is generally up to a maximum of 60 per cent. In certain cases, the owner of the work may benefit from the simultaneous intervention of both the Ministries—here again the maximum rate does not exceed 60 per cent. On the other hand, following exceptional floods, an inter-ministerial decision may raise the total State grant to 80 per cent. It is, however, absolutely necessary that whatever may be its administrative status in relation to the river concerned, each administration remains the sole judge to determine the importance of the interests involved in each case for determining the contribution towards the grants after an economic study.

19.7.5. *Hungary*

Flood protection as well as all other hydrological works and water management are regulated by the Water Law. When there are low floods, the protection of levees is carried out under the direction of the President of the National Water Authority and during high floods, under the direction of the Flood Control Commissary by the technical staff and equipment of the District Water Authorities on the basis of flood control plans as well as in accordance with the procedures laid down by the national flood control regulations. In case of floods, the task of the State Administration is also regulated by Law. The Administration manages the necessary task of labour, traffic, food production, public health, occasional evacuation and resettlement and rescue work in strict co-ordination with the activity of the State Hydrological Organs according to the instructions of the Government Commissary. Four warning stages are prescribed by the National Flood Control Regulation for the accomplishment or flood control. These are Nos. I, II, III and extra-ordinary flood warnings. The commencement of these warnings is indicated by the water levels of the gauge stations corresponding to each station. Detailed flood control plan is elaborated for each region as well as plans for localisation, evacuation and rescue work in the event of a disastrous inundation.

The flood control in the country falls within the scope of the activities of the State. It is performed by designing, constructing and maintaining the engineering structures for flood control as well as by protecting them during floods. This task is accomplished by the National Water Authority along with the Central Organisation for flood Control and Drainage construction enterprises as well as with the regional organs of the 12 District Water Authorities.

Flood embankments and appurtenant works of State properties, their maintenance and development, as well as possible construction of new ones are charged to the National Budget. Their earnings are also the income of the State.

River Law (Law No. 167, 1964) is the main law in connection with flood control and flood plain regulation or management. The objectives of this Law are to contribute to land conservation and development of the country and thereby to maintain public security and promote public welfare by administering rivers comprehensively to prevent occurrence of demage due to floods, high tides, etc., utilise rivers properly and maintain normal functions of the river water.

Rivers are divided into two classes: Class A and Class B rivers. Class A rivers relate to such water system as are specially important from the viewpoint of land conservation or national economy. Class B rivers relate to water systems other than those designated as Class A but have important bearing on public interest. Class A rivers are administered directly by the State (the Ministry of Construction) and Class B rivers by the Prefectural Governors.

In principle, the expenses necessary for administering a Class A river are borne by the National Government and those necessary for administering a Class B river by the Prefectural Government concerned. There is a specified Multi-purpose Dam Law (Law No. 35, 1957) which provides for regulations applicable to some of the provisions of the River Law in connection with the construction and administration of multi-purpose dams and to create the 'Dam using right' so that the use of multipurpose dams may yield prompt and full benefits.

There is also a Flood Defence Law which deals with flood forecasting and flood warning.

19.7.7. *Republic of China*

Flood Control and all other water resources development and hydraulic works are regulated by the Republic of China. To cope with the specific condition of the Taiwan Province, a River Management Rule was promulgated. An agency on various administrative levels has been set up in charge of and for the planning, construction, operation and maintenance of the flood control works in its respective jurisdiction.

The Flood control and other hydraulic works of an inter-province river basin or works of great importance within the same province which cannot be undertaken by suitable local agency have been made the responsibility of a specific agency under the Central Government. Similarly works involving more than one prefecture and those within one prefecture of a very important nature and which cannot be undertaken by that prefecture, can be carried out by a provincial agency set up for this purpose.

The Government can collect taxes from the benefited people in the concerned region and require adult men in the region to do work for specified number of days, each year, under special emergent conditions such as flood fighting and for minor general repairs of embankments. Any act or attempt that could damage or harm to flood control works can be prevented or punished or demolished. Apart from setting up of agencies on various administrative levels for flood control and other hydraulic works, rivers are divided into sections and sub-sections for being looked after by the respective prefectural/country Government authorities for minor repairs, patrolling and flood fighting during the flood period. Technical instructions are also issued by the appropriate specialised agencies of the region.

Flood plain regulations have been mainly enforced by the prefecture Governments with limited success for meeting the acute need of land for industrial, commercial, residential and agricultural developments.

In the evaluation of the new works, an assessment of the benefit cost ratio is generally made with only direct damages and loss taken into consideration. The annual cost include amortization interest on investment, costs attributable to operation and maintenance and interim repairs/losses and insurance costs.

Before 1964, the State paid for flood control projects except the contributions by the benefited people or the local Government to the extent of right of way of the project and some common labour. Annual minor repairs, patrolling and flood fighting during flood periods used to be the responsibility of the people of the respective areas. However, annual repairs, rehabilitation and improvement of flood control works used to be the responsibility of the State and it used to be distributed among the various agencies according to the Water Law and the River Management Rule. Land in the river bed is leased to farmers for raising crops during the season and the rent collected used for the river administration and maintenance costs. However, since 1964, 10 to 20 per cent of the total investment of new projects has to be contributed by local interests. A flood control of one billion dollars has been established to meet the needs of these local interests. If they cannot provide their due share, they may ask for loan at low interest from the fund and repay it in a number of years.

19.7.8. *United Kingdom*

The responsibility for flood control lies with the river basin authorities. They derive powers to construct flood prevention works from the Land Drainage Act of 1930 and subsequent Acts. The revenue for these works is financed by local taxes levied through the local government system on behalf of the river basin authorities, and by payments from internal drainage boards. Grants are also available from the national government through the Ministry of Agriculture for new works or for the improvement of existing works.

19.7.9. *USSR*

Measures for prevention or elimination of the adverse effects of flood inundation are regulated by the Basic Principles of Water Legislation of the USSR and the Union Republic. The Legislation charges the authorities of water enterprise, the organisations and institutions with obligations to carry out in a co-ordinated manner the administration of water regulation, utilisation and conservation; enjoins measures for prevention or elimination of the adverse effects of water and floods on banks, levees and other works, on low lying lands, on swamps and salinization, on soil erosion, gullying, sloughing, mudflows and other damaging phenomena. Urgent measures aimed at prevention or elimination of hazardous and adverse effects caused by water are carried out on the basis of this legislation. Measures for prevention and elimination of these adverse effects are envisaged in the State's National Economy Development Plans.

The USSR Ministry for Reclamation and Water Management as well as the like-named Union Republican Ministries and administration bodies for reclamation and water management are engaged in actual flood control and are responsible for the conduct and supervision of investigations, design and construction of flood control projects. These bodies determine and accordingly carry out the erosion and mudflow control works and bank stabilisation works. All these works are state-financed. Construction is carried out according to the General Plan for flood and erosion control works.

19.8. Appraisal

Most of the countries have enacted basic legislation on the regulation and control of rivers under which flood control works are undertaken. Notable among the countries which have such legislations are the USA, Austria, Canada, France, Federal Republic of Germany, Hungary, Japan, Mexico, Korea, UK, Federal Acts have been supplemented by local or special regulations.

19.8.1. *Scope of legislation*

Flood control legislation, however, is not comprehensive in any country except the USA. In the United States, flood control legislation has been undergoing constant revision and updating in response to developing situations and concepts of floods control. Accordingly, the USA has enacted laws for prevention of encroachments, flood plain-zoning, flood insurance, soil conservation etc. The present position in respect of some important aspects of flood control legislation is summarised below:—

(i) *Flood Plain Zoning and Regulation*

Legislation on flood plain zoning has been enacted in USA, France and China.

(ii) *Compulsory evacuation in emergency*

Recognising the usefulness of non-structural methods of flood mitigation, legislation providing for forcible evacuation of population from flood threatened areas, has been enacted by one provincial Government in Canada.

(iii) *Obstruction to flow*

The USA and France have legislations for regulation of construction of all works which cause or can cause obstruction to flow in a river.

(iv) *Financing and flood levy*

Government finances the flood control works at national, State, district and local levels in most countries. However, in a few countries like Austria, China and France, a per centage of the cost is borne by the beneficiaries. In some countries beneficiaries are required to reimburse to the Government the initial cost of construction wholly or partly whereas in other countries like Columbia, maintenance and operation charges are borne by them. Cost of works is shared by beneficiaries in France, whereas in China a tax an be leived under the law. Legislation for obtaining finances from beneficiaries by way of axes exists also in the UK in the form of Land Drainage Act, 1930.

9.9. Need for comprehensive legislation in the States

The legislative powers of the Union and States vith regard to flood control have been discussed. It was observed that the Central Government has over-riding powers vide entry 56 and 24 of 'Union List' and can enact laws for the purpose of regulation of inter-State rivers. An examination of the existing Acts in different States shows that even though there is a multiplicity of State laws relating to irrigation and water resources, these enactments do not deal with all aspects of flood control.

Since flood damage is on the increase and all available methods have to be adopted to reduce losses, we feel that the States should enact one comprehensive legislation on flood control incorporating provisions to deal with all aspects. We, therefore, recommend that the Central Government should prepare a comprehensive 'model bill' on flood control, which could serve a guide for enactment of suitable legislations by the States.

19.10. Model Bill on Flood Control

The Model Bill should be comprehensive and have suitable provisions for adopting all kinds of flood mitigation measures viz., engineering and other measures to physically control the floods and administrative measures to reduce the losses due to floods. Taking into account the provisions already existing in some of the State Acts and our recommendations in different chapters, the model bill should deal with the following aspects:—

(i) Preparation of flood control schemes.

(ii) Acquisition of land and property.

(iii) Land use regulations in flood plains.

(iv) Prohibition and removal of obstruction in the river.

(v) Disaster Prevention and Preparedness.

(vi) Compulsory evacuation of people and property from areas in danger of floods.

(vii) Requisition of labour at times of emergency.

(viii) Contribution by beneficiaries.

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ANNEXURE 19 (i)

State-wise position of legislation in respect of flood control.

State	Legislation vesting authority to under take the work or initiate the scheme	Legislation regarding prohibition and removal of obstruction to flow in a stream	Legislation for imposition of flood cess/ contribution by beneficiaries	Legislation on soil conservation other than Central Legislation	Remarks regarding legislation on other aspects
1	2	3	4	5	6
Andhra Pradesh	No legislation. However, one Act known as Drainage Cess Act, 1968 was enacted under which Krishna Godavari Delta drainage was undertaken. This Act applies to all lands in delta area of Krishna & Godavari rivers.	Madras River Conservancy Act, 1884.	Andhra Pradesh Irrigation (Levy of betterment contribution Act, 1955).	Nil	1. *Flood Plain Zoning* No State except Manipur has enacted any legislation. 2. *Compulsory evacuation during floods.* No State except UP has enacted any legislation.
Assam	Assam Embankment Act, 1953 as amended in 1954 and 1966.	Nil	Assam Embankment Drainage Act, 1953.	Nil	3. *Requisition of Labour.* Provision is made in Northern India Canal & Drainage Act, 1973 applicable to U.P. Haryana, Punjab & Delhi.
Bihar	(1) Bihar Public Irrigation and Drainage Works Act, 1947. (2) Bengal Embankment Act, 1882.	(1) Bengal Irrigation Act, 1876.	Bihar Irrigation & Flood Protection (Betterment Contribution) Act, 1959.	Bihar Soil & Water Conservation and Development Ordinance, 1977.	4. *Deforestation.* Punjab, Karnataka, Maharashtra, Rajasthan, UP have separate legislation in addition to Indian Forest Act,
Gujarat	Bombay Irrigation Act, 1873.	Bombay Irrigation Act, 1879.	Nil	Nil	5. *River Conservancy.* Only Tamil Nadu has Madras River Conservancy Act, 1884 which is also applicable to Kerala, Karnataka and Andhra Pradesh.
Haryana	1. Haryana Canal & Drainage Act, 1974. 2. Northern India Canal and Drainage Act, 1873.	Northern India Canal and Drainage Act, 1873.	Northern India Canal and Drainage Act, 1873.	Punjab Land preservation Act.	6. *Land Acquisition* Assam, Bihar, West Bengal have separate legislations for land acquisition in addition to the central Act, i.e. Land Acquisition Act, 1894.
Himachal Pradesh	NA	NA	NA	NA	

1	2	3	4	5	6
ammu & Kashmir	The Canal & Drainage Act, 1906.	1. The Canal & Drainage Act, 1906. 2. Public Eviction Act.	The Canal and Drainage Act, 1906.	Land Improvement Act, 1972.	
Kerala .	Travancore Cochin Irrigation Act, 1956.	Madras River Conservancy Act, 1884.	Travancore Cochin Irrigation Act, 1956.	Nil	
Karnataka	Mysore Irrigation Act, 1965 (Karnataka Irrigation) Act, 1967.	Mysore Irrigation Act, 1965.	Mysore Irrigation Act, 1965.	Nil	
Madhya Pradesh	Nil	Madhya Pradesh Irrigation Act, 1931.	Nil	Nil	
Maharashtra .	Maharashtra Irrigation and Drainage Act, 1976 (Bombay Irrigation Act, 1879).	1. Maharashtra Irr. Drainage Act, 1976. 2. Maharashtra Land Revenue Code 1966	Nil	Nil	
Manipur .	Assam Embankment Act, 1953	Manipur Flood Plain Zoning Act, 1978.	Assam Embankment Act, 1963.		
Orissa .	1. Orissa Public Embankment Construction and Improvement Act, 1951. 2. Orissa Hydro-electric Projects and Flood Control Works (Survey) Act, 1961.	The Orissa Irrigation Act, 1959.	Orissa Public Embankment Construction and Improvements Act, 1951.	Orissa Soil Conservation Act.	
Punjab .	Northern India Canal and Drainage Act of 1873.	Northern India Canal and Drainage Act, 1873.	Northern India Canal & Drainage Act.	Punjab Land Preservation Act.	
Rajasthan .	Rajasthan Irrigation and Drainage Act, 1954.	Rajasthan Irrigation & Drainage Act.	Rajasthan Irrigation and Drainage Act.	Rajasthan Soil and Water Conservation Act 1953.	
Tamil Nadu	Nil	Madras Conservancy Act, 1884	The Madras Irrigation (Levy of Betterment Contribution) Act, 1955.	Tamil Nadu Land Improvement Act, 1954.	
U.P.	Northern India Canal and Drainage Act.	Northern India Canal and Drainage Act.	Northern India Canal & Drainage Act.	Soil and Water Conservation Act, 1963.	
West Bengal .	(1) Bengal Irrigation Act, 1876 (2) Bengal Embankment Act, 1882.	Bengal Irrigation Act, 1876.	Bengal Embankment Act, 1882.	Nil	

XX. COLLECTION & PUBLICATION OF DATA

20.1. Introduction

In Chapter XV the need for data collection to facilitate planning and preparation of schemes for flood control and flood forecasting has been indicated. The statement of policy outlined by the Union Minister of Irrigation and Power in September 1954 emphasised the need for collection of basic technical data for formulating short and long term flood control programme.

The High Level Committee on Floods, 1957 also stressed the need for collection of reliable data. The Ministers' Committee on Flood Control 1964 concluded that there was a great need for continuous recording of hydrological data and collection of topographical data on the basis of aerial maps. Data is also needed for evaluating the effectiveness of the works constructed. Some data are required with a lead time.

20.2. Types of data

An overall water resources development plan requires the basic data covering a wide-range and many disciplines. For planning and desig of only the flood control component of such plan the basic data required would be mainl hydrological and topographical. In additio land resources, engineering, human and economi data would also have to be collected and analyse for individual projects.

20.3. Hydro-meteorological data

20.3.1. *Rainfall*

Rainfall data for long periods are required fo developing rainfall-runoff relationship whic along with the unit hydrograph will help in th estimation of maximum possible or probabl flood, determination of floods of different frequen cies and forecasting of flood stages in flood fore casting operations. This requires the plannin of a network of rainfall stations with utmos care. The World Meteorological Organisatio has established guidelines for determining th minimum density of rain gauge network a under:—

Min. density of network (area in sq. km. per station)

Adequate network			Tolerable in difficult conditions		
Flat region of temperate Mediterranean and tropical zones	Mountainous region of temperate mediterranean & tropical zones	Arid Zone			
Region I	Region II	Region III	Region I	Region II	Region III
600—900	100—250	1500—10,000	900 to 3,000	250 to 1,000	Not given

The World Meteorological Organisation have also suggested that the minimum density network of rain gauge stations should consist of three kinds of rain gauges (i) standard gauges non-recording to be read daily or at any predetermined intervals depending upon operational requirements; (ii) self-recording gauges at least 20 per cent of the rain-gauge in the network should be self-recording, and (iii) storage gauges in some locations, where it is important to obtain data but due to lack of facility of communication and regular observation, a standard gauge cannot be installed. A gauge with large enough capacity which may be read monthly or six monthly may be installed at such locations.

The High Level Committee on Floods had recommended the establishment of a minimum of one Station for every 200 sq. miles (518.5 sq. kms.).

As on 31-3-1979, there were 1092 ordinary and 614 self-recording rain-gauge stations maintained by the India Meteorological Department. There are 3791 ordinary rain-gauge stations maintained by States and other organisations. Also, there are more than 4000 non-reporting stations where data is not being reported to the Indian Meteorological Department. Only 225 ordinary and 35 S.R. rain-gauge stations are located in hilly regions.

20.3.2. (i) The present coverage of rainfall sta tions in the plains is generally satisfactory in al the States except the Rajasthan and Himacha Pradesh. However, the coverage in hilly areas i inadequate and we, therefore, recommend tha the network in hilly adea should be streng thened.

(ii) At present self-recording rain-gauge net work constitutes nearly 10 per cent of total rain gauge stations. It is recommended that the num ber of self-recording rain-gauge stations shoul be increased so that the density of the networ is increased to 20 per cent.

(iii) Apart from the general network, there i need to design small operational rain-gauge net works to suit the specific requirements of floo forecasting. This may be planned and installe as necessary.

(iv) The India Meteorological Department ha developed indigenous radio-reporting rain gauges. We recommend intensification of deve lopment efforts as date on real time basis fron hitherto inaccessible areas would be very use ful for flood forecasting.

20.3.3. *River stage discharge and sediment*

The need for extensive collection of strear flow data on a scientific basis was realised afte

Independence and many stations were established for specific projects. After 1954, however, greater emphasis was laid on the establishment of these stations on major rivers like the Ganga and the Brahmaputra.

The Central Water Commission started a systematic programme of collection of hydrological data in Assam in the Brahmaputra Valley by establishing hydrological stations at selected points. This work was subsequently handed over to the State Government. After the establishment of the Brahmaputra Flood Control Commission in 1970, this work has been further intensified and regular data is being collected from the sites maintained by the basin States.

The Ganga Basin Water Resources Organisation was established for collection of scientific and reliable data for the Ganga Basin. This Organisation, which has now been merged with Central Water Commission is observing data at 179 sites on the Ganga Basin.

Consequent upon the recommendation of the Krishna Godavari Commission, the Central Water Commission also launched a programme of hydrological data collection by establishing 74 stream gauging stations in the Krishna and the Godavari basins, of which 41 were also sediment observation sites. Sixty-seven more key stations were added in 1973 in basins other than the Ganga, the Indus, the Krisha and the Godavari. During the 5th Plan, 80 more sites were programmed to be added. It is planned to bring the network of stream gauging to the minimum norms laid down by World Meteorological Organisation as shown below:—

Terrain	Norms recommended by WMO
1. Flat region	One station for 3000 to 10,000 Sq. km.
2. Hilly region	1000 to 5000 Sq. km.
3. Arid region	No norms

A statement showing the number of hydrological stations maintained by CWC and those required as per WMO norms for basins other than the Ganga and the Indus is appended as Annexure 20(i).

In addition, the Central Flood Forecasting Organisation of the CWC is observing gauges/discharges on inter-State rivers during monsoons for the purpose of flood forecasting.

The States have their own stations in a number of river basins. A statement showing the position appears as Annexure 20(ii).

20.3.4. (i) The CWC has made good progress in the establishment and operation of hydrological stations on many rivers. However, the existing network in the entire country needs to be reviewed and a comprehensive network drawn up in consultation with the States and other agencies with a view to bring the network to standards laid down by WMO or standards accepted for the country. A river or major tributary should be taken as the unit and sites designed to get maximum benefits for use in development of irrigation, flood control, flood forecasting, power development, navigation, fisheries etc.

(ii) To formulate this comprehensive network, a special task force should be appointed as early as possible, a time schedule should be fixed for finalising this network and then for implementation by the States as well as the Centre so that the network comes into operation in a period of, say, 5 years.

(iii) Though the primary responsibility of data collection in respect of river gauges, discharge, sediment load etc., should continue with the States, the CWC should be able to exercise technical direction in respect of the stations in the States so as to ensure uniformity and continuity. This would also avoid duplication of efforts.

(iv) The CWC should also extend the network of key-gauging stations in its charge so as to cover all the regions according to needs and carry out frequent checks with data collected by State and other agencies at nearby sites. A suitable mechanism of checks has to be evolved so that reliable data is made available for future planners. Extension of the network and observations thereof should be done by the establishment of regional centres as recommended in para 20.9.1. for collection, processing and storage of data.

(v) The key-stations under the States and other agencies should be equipped with automatic gauges in a phased manner so as to complete this automation within the next 5 years, as recommended in para 20.7.4. Such of the stations as are of importance in flood forecasting for flood-prone areas should be equipped with telemetering facilities so as to enable the forecasting stations to get real time data on a continuing basis.

(vi) The data collection of all important and inter-State rivers should continue to be undertaken by the Central Water Commission till the formation of River Basin Authorities, when the matter could be reviewed.

20.4. Topographic data

20.4.1. Topographic maps are indispensable tools for the planners of water resources development in general and for formulating flood control measures in particular. A flat land or flood plain would need to be mapped to a scale of 1:10000 with contour intervals of 0.3 to 0.5 metres. With such maps the areas likely to be inundated, the structures needing protection, etc., can be marked out clearly. Small scale topographic maps with significantly large contour intervals could introduce errors into plans and designs, that would make it impossible to arrive at a meaningful choice from amongst alternatives or even to draw conclusions of technical feasibility. Information from topographical maps may also influence the range of choices for a flood control measure. The best alignment of flood banks or drainage channels is totally dependent upon accurate information regarding levels and distance as determined from topographic maps; so also, for regulating activities in danger zones and areas vulnerable to floods.

Topographic surveys also include river surveys. A change in river course, silting and scouring of the river bed, configuration of the flood bank, etc., need to be surveyed regularly and at specific intervals of time, say, 2 to 5 years depending upon the rate of change. River profiles and cross sections at adequate intervals should be developed every year in selected reaches of the flood prone rivers. These surveys will provide information for designing new flood control measures or checking the adequacy of past measures.

Collection of topographical data was stressed in the National Flood Control Policy enunciated in 1954. This was followed by sustained efforts at Central and State levels for a few years, as reflected in the progress reports submitted to the Central Flood Control Board. Aerial surveys, covering more than 50,000 sq. miles (1,30,000 sq. km) in the Ganga and the Brahmaputra basins were carried out. Photomosaics were prepared for about 40,000 sq. miles (1,04,000 sq. km) covering areas in Uttar Pradesh, Jammu & Kashmir, Punjab and Bihar. The erstwhile CWPC carried out level surveys for the Bagmati, the Kamla and the Burhi Gandak in Bihar to the extent of 12,500 sq. miles (32,500 sq. km) and 10,700 sq. miles (27,820 sq. km) in Uttar Pradesh covering some areas in the Ghagra and the Rapti basins. The Ghaghra basin has now been fully contour surveyed. An area of about 70,000 sq. km has been covered by contour plans and photomosaics in West Bengal.

Contour plans to a scale of 4" to 1 mile (: 16000) with 1 ft. (0.3 m) contour have been completed for an area of 10,000 sq. miles (26,000 sq. km), covering the Kopilli, the Puthimari, the Jagaliadiay basins etc., in the Brahmaputra and the Barak basins in Assam. Aerial surveys were also carried out for a distance of 8 miles (12.84 km) on either side of main Brahmaputra for the study of erosion problem. Contour plans with 3 ft. (0.9 m.) intervals have been prepared for the entire Manipur valley.

Contour plans of flood plains above Srinagar have been almost completed, whereas the Tawi, the Chenab and the Uja river basins have been partially covered in Jammu & Kashmir. In Haryana State most of the river basins have been covered by contour surveys while contour plans of the Kamapahari, the Banganga and the Gambhiri basins in Rajasthan are under preparation.

In the Mahanadi basin, only some areas in the delta region near Cuttack and parts of the Subarnarekha have been contour-surveyed.

20.4.2. (i) The position regarding topographical and river surveys in the flood-prone basins of the country is not satisfactory. Noting that they are important in the preparation of master plans and delineation of flood prone areas which is a predequisite to undertake flood plain zoning, we feel that detailed surveys and preparation of contour maps of the flood-prone areas cannot be postponed. We understand that the question of carrying out contour surveys of flood-prone areas in the Central Sector is being actively considered in the Ministry of Energy and Irrigation (Department of Irrigation). We endorse this proposition.

(ii) For this purpose the Flood Control Department of the State should immediately take stock of the situation and make out a list of areas still remaining to be contour surveyed by the Survey of India and indicate priorities. The Flood Wing of the CWC should consolidate the work required to be done in different States in consultation with the Survey of India and draw up a suitable programme with priorities, so as to enable the Survey of India to complete the contour survey of all the flood-prone basins in the country in the next 5 to 10 years.

(iii) River surveys including L section and cross sections at fixed intervals are essential for important reaches of flood-prone future planning and evaluating the effects of existing works and taking timely steps, where necessary. This work should be carried out systematically by the Flood Control Departments of the States.

20.5. Additional data for specific project formulation.

20.5.1. In addition to the above data which is required to be collected on a continuous basis, there is need to collect the land resources data, engineering data, socio-economic data for specific project formulation.

20.5.2. *Land resources data*

In the context of the comprehensive approach to floods land resources survey needs to be carried out in all flood-prone basins for developing land use plans and programmes for proper land management. In the protected flood plains where soil surveys have not yet been carried out, the same should be taken up in order to obtain physical and chemical properties of soils so that intensive production programmes with irrigation can be taken up. With a view to determine the agricultural productivity of crop land in the flood plains, both protected and unprotected, statistics of crop production have to be collected. Uptodate land resource survey for the upper catchments of flood-prone rivers are also considered essential in order to develop scientific basin plans. Information on land use, vegetative cover, extent of erosion etc. are called for. We, therefore, recommend that land resources surveys for the catchments of the flood-prone rivers should be taken up on a priority basis using where feasible, modern technology like satellite imagery, remote sensing etc.

20.5.3. *Engineering data*

In addition to the data discussed earlier information of a strictly engineering nature is required to plan structurally sound and economical schemes. This will involve investigation of construction materials available and their properties/suitability in construction. Investigations and data for foundation conditions in respect of different engineering solutions will also be necessary. Sometimes data would be required for model studies.

20.5.4. *Socio-economic data*

The construction of a project by itself does not serve much purpose unless the people who are to be benefited by it know the utility of the project and utilise the resources created by it. In case of the flood protection measures the people concerned must feel that the project will give them benefit. Similarly where irrigation is also contemplated and the people are not used to irrigation, it would be necessary to educate them. It may also be necessary to educate them about improved farming etc. So before a project is prepared a survey of these factors should be made so that the project serves the purpose for which it is meant.

All basic data have varying degrees of economic implication. Basic data on the economics of water resources development including flood control provide the necessary inputs for use in the assessment of the needs of the people and lead to a determination of the degree to which the goals of the development can be achieved. Basic economic data are also essential for identification of alternate means to meet the needs when feasible and achieve the desired goals.

We need information for proper evaluation of the historical trends of economic activity in the project area and an analysis of the current level of economic activity so that we now where we have been in the past and where we are now, before formulating proposals for the future. Many policy decisions have a direct bearing on the developmental activity such as the income levels, land tenure programme, policy on subsidies and repayment priorities for industrial and agricultural development.

Of all the economic data that we have mentioned above, we would like to lay stress on the data on flood damages being carefully collected every year.

20.5.5. In view of the importance of collection of flood damage data on a continuous basis, we emphasise the need for implementing the recommendations made in Chapters VII and VIII.

20.6. Modern advances in collection of basic data

New technologies have been developed in recent years for the collection, transmission, storage and retrieval of basic data and are available to the engineer for developing new ways of measuring the parameters which are essential requisities for planning flood control works. Amongst the most significant advances made over the past decade are: automation of data collection and telemetry to base stations, measurement of rainfall, stream velocity and soil moisture by rador, remote sensing by camera and geophysical sensors from aircraft and satellites; automation of data storage, processing, and retrieval by use of digital computers, electric analogs and digital computers to simulate hydrologic systems and for complex water resources analyses. These could relevantly be made use of.

20.6.2. *Automatic recording stations*

In spite of the many advances and new technologies developed so far in connection with observation, transmission storage and retrieval of basic data, functional observation stations cannot be avoided. In many regions, the need for such ground stations would increase with the increase of coverage with modern technologies. Many ground statics will have to be established in remote areas and the maintenance of these isolated stations will be a major problem. This difficulty is being solved by setting up stations which automatically transmit the data by radio. The IMD have developed indigenous Radio Reporting Raingauge instruments and 8 of them have already been installed in the Narmada and the Tapi basins. Their performance has, however, not been up to the mark so far. It is necessary to lay greater emphasis on the development and establishement of more Radio Reporting Raingauge stations than has been done hitherto, as they can be very useful in getting the rainfall data from inaccessible area on realtime basis.

Automatic water level recorders have also been indigenously developed, and are being used in the Central Flood Forecasting Organisation of the Central Water Commission. Their number is, however, very limited and has to be gradually increased. The CW&PRS, Pune have developed water level recorder and three such recorders have already been manufactured by them for use. One of them has been installed at Patna and the other two are planned to be installed in the Yamuna at Delhi and Sabarmati at Ahmedabad. This water level recorder can also be used as a remote sensing platform for satellite telemetry. It is recommended that, after their success is proved, such recorders should be manufactured and installed in large numbers.

20.6.3. *Radar*

Radar has three possible applications in flood management (a) Quantitative measurement of rainfall (b) Measurement of stream velocity and (c) Measurement of soil moisture.

Unlike the normal precipitation network, which measures rainfall at scattered points, the radar makes it possible to measure rainfall over a large area. Experience has shown that it is possible to obtain good quantitative measurements with a 10 cm. radar which can satisfoctorily cover a range of 100 km. and with fair results up to 200 km. The radar will not eliminate the conventional precipitation network, but will enable a much greater accuracy of actual rainfall recorded besides eliminating the time lag in reporting.

For the measurement of velocity, the ground based radar can be used to monitor floating ceramic balls coated with a metallic oxide. The measurement combined with cross sectional area can be used to determine river discharges. Similarly, soil moisture can be obtained on the basis of the VHF reflective properties of the soil under different conditions. A very short pulse radar mounted on a ground vehicle is used for this purpose.

20.6.4. *Aerial photography and remote sensing*

(i) For quite some time, direct photography of the area from the air has been used for collecting information about topography, drainage works, etc. Recently, the technology of remote sensing has been developed and widely used for the collection of basic data by aerial photography. The method involves the use of aircraft and spacecraft as platforms for sensors which are special devices like multiband cameras and radiometers, which are capable of recording the reflected or emitted radiations from soil or water below or measure the electrical signals from ground stations known as Data Collection Platforms.

Several characteristics of water make it particularly amenable to investigations by remote sensing devices. For example, clear water readily transmits and absorbs solar radiations while heavy concentration of sediment will reflect much of the solar radiation at visible wave lengths but continue to absorb near infra-red energy. Water also has the highest specific heat. So, thermal sensors can detect the presence of water by identifying cool areas in warm days or warm areas in cool nights. Soils also have different reflectance characteristics depending upon whether they are wet or dry. Thus by proper analyses of remote sensed data, it is possible to arrive at useful conclusions for use in planning. This analysis is possible if the concerned engineer is familiar with field conditions as this enhances the ability to interpret the remote-sensed data. Quantitative hydrological measurements on ground are required to confirm the accuracy.

Different types of sensors such as multi-band cameras and single cameras, radio meters, thermal scanners, multi-spectral scanners, micro-wave energy sensors are used in remote sensing. Remote sensing data can be collected in either analogy (image) or digital from depending upon the equipment available and the type of project. The analogy data is analysed by photo interpretation techniques which make it comparatively cheap, simple and rapid and is particularly useful for flood control purposes. The digital data is processed by computer and is useful in more elaborate type of analyses.

Remote sensing using the sensors can be done with the help of air craft or satellites with platforms. Aerial photography using air planes or helicopters can be used when limited data is required for a limited area at selected times. Such data may range from inexpensive photographs taken from windows of the aircraft or imagery or data from an assembly of sophisticated scanners.

Remote sensing from air craft has a wide field of application in collection of flood data.

(ii) There are two organisations working in the field of remote sensing.

A. *Indian Space Research Organisation, Ahemedabad.*

This is a Research and Development Organisation, working on Satellite Development Programme. It has already launched the 2nd India Experimental Satellite for Earth Observation (SEO). Data collection platforms have been established in selected locations in close consultation with the Central Flood Forecasting Organisation to obtain information in respect of variations in gauges, levels and extent of inundation.

forts are expected to be made to correlate the ata from satellites with those of ground condions. The following capability has been deveped.

(a) Aircraft mission using multiband camera systems (only for 70 mm format).

(b) Multispectral scanning system (MSS) with 5 bands and a thermal scanner (one band) for aircraft operation.

(c) Data collection platforms for Satellite for Earth Observation operation.

They claim to have developed capability in espect of mapping of flood plains and river and rainage courses as also land use, assessment f physicol damage caused by floods and collecion of data for flood forecasting.

3. *National Remote Sensing Agency (NRSA)*

This agency has flight facility at Bangalore, itted with sophiscated cameras and multi-scanners for aerial photography as well as multipectral scanning at medium and high altitudes. Some of the projects handed by NRSA are:—

(a) Remote sensing survey of upper Barak river watershed for N. E. Council.

(b) Survey of area involving three drought-prone districts of Karnataka and West Coast area from Ratnagiri down to Kanyakumari.

(c) Land use map of certain areas of Orissa to a scale of 1:250000.

(d) Air-borne multi-spectral scanner survey of the Kosi river in the 1977 floods.

This agency has also obtained Landsat computer compatible tapes and transparencies of imageries covering the entire country. For some areas, they have also repetitive imagery. The agency has recently installed sophisticated in--teractive multi-spectral data analysis (MDAS) for processing satellite computer compatible tapes as well as aerial modula-multi-special (M25) data tapes. A printer/plotter system for plotting maps or printing from processed Landsat or aerial data is also installed for facilitating interpretation of multi-spectral imagery by colour enhancing techniques. Necessary labortory facilities are being developed for image analysis and production.

(iii) Some examples of actual application of remote sensing imagery from Landsat in connection with flood control in USA are given below:

(a) *Mapping of flood affected areas*

A number of investigations have shown that it is possible to delineate flood boundaries using Landsat data either during floods, or shortly afterwards. This was done in case of Mississippi river in 1973 when it was possible to map the area inundated along the entide river for a length of 2000 km.

It was further applied in the case of the Indus river where 4 flood-waves in successive days were recorded. Through special arrangements the data was made available in a few hours. By using special techniques of processing, maps were prepared which exhibited flooded areas, changes in river channels and other related information.

In India, air-borne multi-spectral scanner surveys were carried out for the Kosi river after the floods of 1977 and mapping of inundated areas in respect of the Sahibi river in 1978.

(b) *Water level fluctuations*

Landsat imagery has been used to depict water level fluctuations, lake areas and water volumes for Shiraz and Nerisplaya lakes in Iran.

(c) *Rainfall run-off coefficient*

After analysing from Landsat imagery the drainage basin characteristics like land cover, extent of vegetation, deforestation, type of strata, layout of drainage pattern etc., it was possible to develop runoff coefficient for Chikasha area of Oklahama. It is reported that observed values approximated more closely to those computed in this way, than those by conventional methods. This application, however, is still in its research stage.

(iv) The use of satellites for meteorological purposes has already reached an advance stage and a system has been in operation whereby weather over the whole earth is photographed at least once daily and information is made available to all countries of the world under 'World Weather Watch' programme. Geostationary system of satellites, spaced around the equator hold promise to usher a new era in flood forecasting.

20.6.5. Taking into account the modern advance we feel that even though we cannot afford to compete or emulate some of the advanced countries, in the scale and scope of modernisation achieved, it is essential to make a steady and systematic advance in that direction so as to promote efficiency and economy in our work.

We also feel that there is immediate need for the installation and operation of more telemetering devices both in our rain-gauge and river-gauge net work. The work being done by the IMD and the CWPRS in this direction should be intensified and necessary financial support provided so that with a 5 years time-bound action plan, major flood forecasting centres should be equipped with these facilities. We further recommend that for assistance in flood forecasting work, 10 cm. radar should be installed at suitable places.

20.7. Data handling, storage processing and retrieval

20.7.1. *Modern trends*

The methods of handling data are decided by the speed and frequency with which they are required and the cost involved in the process. For example, river gauge observations for flood warning are to be transmitted instantaneously, but discharge observations which would need a lot of computations need not be transmitted with such urgency. Usually the data collected are not automated and people are employed for observation, recording, transmitting, research, publication, and storage. Recent advances have, however, made it possible for automatic instruments and digital computers to play a big role in these operations.

Principally, the data collected manually are converted to digital form for entering into computer processing. This is done by punching data cards or by using the pre-perforator on a teletypewriter circuit that brings the data to the forecast centre from collection centres. The digital data are combined with similar data collected automatically and all receive a visual quality control inspection and editing. Additional quality control checks can be incorporated in the computer processing programmes. In some countries observation stations have been automated using various communication modes including telephone, land radio and satellite radio.

At automatic river stage stations, water data is collected on punched paper tapes. The transmission network enables the local translation of data to a computer-compatible form and transmitting the translated data over telephone circuits to a central computer facility. The data are then processed by a central computer and transmitted back via a computer terminal located at the transmission site. The results obtained by this procedure are simultaneously sorted in data bank files and printed at the transmission site. The data obtained from the satellite systems are also noted into the files of the data bank. The data bank system consists of several files in which the data are grouped and stored by common characteristics and data collection frequencies. The system is also designed to allow for the inclusion of additional data files. All data files are maintained and managed on the central computer facilities at a suitable central place. However, data may be entered into or retrieved from the data bank through a number of locations that are part of a national telecommunication network.

20.7.2. *Standardisation of methods and equipment*

Measurement, recording and reporting of data, particularly, hydrological data, have to be standardised so that data collected by different agencies is not only comparable but also compatible for the purpose of computer proce sing. Measurement of velocity is usually don by surface floats, velocity rods, current mete etc. However, the methodology adopted b different organisations is not uniform. Lack c uniformity in the data acquisition and handlin methodologies renders the exchange of informa tion between contiguous regions or inter-State international rivers difficult and of limited valu Similarly the equipment used in the collectio of data must also be standardised and manufac tured in accordance with international standard Wherever feasible the equipment should no only be robust in construction but should als be simple in design and easy to operate, takin due note of the level of education of the person nel operating them. There should be standar instructions for the people engaged in the collec tion of data. A regular system of inspections an maintenance should be in-built so that the dat collected conforms to the instructions laid down Standardised forms should be adopted both fo visual observations and autographic records an for specimen calculations and analyses. Standardisation is particularly important when bul of the work is to be carried out by staff no adequately qualified or trained. Standard form for processing and analyses of data are also useful to facilitate the use and interpretation o data to reveal errors and inconsistency at a glance.

Recording of data in standardised forms or cards is very useful for publication of data. As published data often gets lost, publication is the best and the easiest way of ensuring its preservation. Published data has also the merit of being considered more reliable as greater care and scrutiny are usually exercised before publication.

20.7.3. We note that the CWC's hydrological data collection agencies and some States have already adopted the forms evolved by the ISI for gauge and discharge measurements. We recommend that these standard forms should be adopted by other States also. The standardised procedure, practice, formats etc., should be brought into force throughout the country within a time bound schedule and, thereafter, the CWC should ensure its continued application by frequent inspections and guidance to the other agencies.

20.7.4. *Processing*

Data collected on standard forms in the field stations should be carefully scrutinised and checked before they are forwarded to the Divisional Office. At the Divisional Office of the CWC or the State as the case may be the data should be transferred to punched cards. For this purpose, the Divisional Officers should be provided with punching facilities. After an initial check, these cards should be sent for record to the nearest regional centre of the CWC r the Hydrology Cell of the State which will ave to be set up by the States where they do ot have one already. These Centres/Hydrology ells should be equipped with a statistical unit ith arrangements for transferring the punched ata to tapes.

The regional centres of the CWC should be ntrusted with the responsibility of coordinang the data collection programme in the region. hey should collect data from the CWC field ivisions as also from the Hydrology Cells of the tates and should check and store all the data ollected in that region in such a way that the ame can be retrieved for use by another agency n that region. The statistical unit attached o the Centre should arrange the transfer of ata from field data sheet or punched cards to nagnetic tapes or discs. These centres should ollect river data, hydrological data and waterhed data from the concerned department and ll flood damage data supplied district-wise. The ata processing would involve the use of modern omputational machines. We recommend that ne mini-computer each be established at Patna nd Hyderabad to be operated under Chief Engieers, Flood Forecasting and Hydrological Obervations. The rigional centres should also be ntrusted with the responsibility to evaluate he results of completed projects in the light of enefits assumed in any projects. With a view o get all the work done, it is recommended hat the regional centres of the CWC are adequaely staffed with engineering and statistical peronnel.

0.7.5. *Central Data Bank*

A Central Data Bank should be established in he CWC, which should have computer facilities or storing as well as retrieval. For this purpose . separate computer division should be added to he existing statistical unit. The data received rom the regional centres in the shape of comatible tapes should be carefully stored in this Data Bank. Computer facilities should also be uitably extended for the storage and retrieval of data collected throughout the country. Suitable software should be developed in the Central office for processing of data for supply to the different users in the country. The statistical units attached to the regional centres should work directly under the technical control of the Central Office.

A schematic sketch showing the functions of various units of the national hydrological network is given in Annexure 20 (iii).

20.8. **Publication of data**

20.8.1. Hydrologic and economic data should be published so as to be useful to the planners.

The principal agency in charge of observation and maintenance of precipitation data is the IMD. They publish their rainfall data along with that obtained from the States, who also maintain a large number of rain gauge stations. It has been seen from the information furnished by the IMD that there is considerable time lag in the publication of the data due to delays in receipt of data from the States. We recommend that the State Governments should submit rainfall data for past years to IMD with minimum delay and in the future ensure prompt submission of the annual data.

The river stage and discharge data are collected primarily by the Irrigation/Flood Control Organisation of the States and the Central Water Commission, the latter in respect of key guaging stations. Even here, there is considerable delay in the publication of the data. As seen from the reply of the CWC, the publication of wated year books is lagging behind considerably.

20.8.2. We recommend that the States should take immediate steps to publish the available data so that this useful information is not lost. Similarly, the Central Water Commission should make up the lag in the publication of Water Year Books.

ANNEXURE 20 (i)

Statement showing the existing basinwise discharge sites maintained by C.W.C. and those required as per W.M.O. norms excluding those of the Ganga, Indus, Chenab.

River basin	Network required	Sites established under various Schemes	Balance to be set u
1. Kaveri	13	13	..
2. Pennar	9	9	..
3. Krishna	68	36	32
4. Godavari	68	38	30
5. Mahanadi	20	16	4
6. Brahmani	6	6	..
7. Subarnarekha	5	3	2
8. Baitarni	2	1	1
9. Luni	10	1	9
10. Sabarmati	4	1	3
11. Mahi	5		..
12. Narmada	19	19	..
13. Tapti*	10	10	..
14. West flowing rivers	38	1[illegible]	19
15. Desert rivers of Rajasthan	5	..	5
16. Other rivers	18	12	6
17. Brahmaputra	84	32	52
	384	221	163

*Data as supplied by CWC.

ANNEXURE 20 (ii)

Statement showing state-wise distribution of Hydrological Stations.

	Maintained by State*			Maintained by CWC**			Maintained by G.B.W.R.O. of C.W.C.
	Gauge site	Discharge site	Silt site	Gauge site	Discharge site	Silt site	Gauge/ Discharge site
1. Andhra Pradesh	49	49	..	26	26	13	..
2. Assam	263	132	104	13	10	10	..
3. Bihar	227	139	18	4	4	3	35
4. Gujarat	122	76	56	12	12	7	..
5. Haryana	68	NA	NA	NA	NA	NA	5
6. Himachal Pradesh	NA	NA	NA	NA	NA	NA	NA
7. Jammu & Rashmir	27	27	..	..	..	..	4
8. Karnataka	41	41	11	31	31	14	..
9. Kerala	93	3	..	9	9	2	..
10. Madhya Pradesh	93	12	7	31	31	15	22
11. Maharashtra	NA	NA	NA	54	54	21	..
12. Manipur	22	12	1	NA	NA	NA	NA
13. Meghalaya	NA	NA	NA	NA	NA	NA	NA
14. Orissa	188	61	1	17	17	10	..
15. Punjab	3	3	NA	NA	NA	NA	NA
16. Rajasthan	39	8	5	4	4	3	15
17. Tamil Nadu	60	57	..	20	20	3	..
18. Tripura	39	26	..	..	..	..	..
19. Uttar Pradesh	111	54	10	..	..	..	80
20. West Bengal	176	70	51	..	..	..	17
21. Delhi	11	11	..	..	..	..	1
	1632	721	264	221	218	101	179

*Data collected from States' replies to RBA.

**Data collected from CWC.

सत्यमेव जयते

XXI RESEARCH, EDUCATION AND TRAINING

21.1. **Background**

21.1.1. Science and technology promote all our endeavours for progress and human welfare. Its status determines the stage of development of a nation. Using the available knowledge in science and technology, man seeks to solve his problems. The last two decades have witnessed rapid advances in the field of science and technology which, according to estimates made abroad, have almost doubled the scientific knowledge of man. Some academicians feel that at this rate half of the course content taught today at the post-graduate level will become obsolete after five years in the field of natural science and ten years in the case of engineering. In order to benefit from the fast advancing field of science and technology, a developing country like ours should have a dynamic policy on research, education and training as related to our water resources.

21.1.2. Flood is one of our major water-related problems that spells disaster year after year. In spite of measures undertaken so far, the flood damages are on the increase. All the short term measures taken near the disaster sites for immediate relief have alleviated but not solved this chronic problem. After analysing the technical aspects of the problem, we have suggested a basin-wise approach to the problem of flood. In the changed context, a more intensive programme of research is considered necessary. This would call for studies on rainfall-runoff relation, sediment discharge, river behaviour, individually or a group of basins/sub-basins. Equipped with such scientific information, a comprehensive approach through storage, land treatment, etc. could be planned quantitatively. For this purpose, education and training have to be geared up with a view to man the research and development programmes with adequately qualified staff. Equally important is a well-informed public for whom the programmes are designed and who ultimately matter for the success of the national efforts in mitigating flood losses. An appropriate programme of mass education and training on the problem of flood and its prevention measures is, therefore, considered important.

21.2. **Past recommendations and developments**

21.2.1. Since the enunciation of the National Flood Policy, in 1954, many Central and State Committees have examined the problem of floods. In its report, the High Level Committee, 1957 recommended that flood control schemes should fit in with the plans for other water resources developments as far as feasible and the State's proposals for enbankments should be studied in detail to determine their effect on the river basins before accepting their inclusion in Plan programmes. The basic need for hydrological data and scientific planning has also been pointed out by the Committee.

21.2.2. The Ministers' Committee on Flood Control, 1964 briefly dealt with the need for trained technical personnel and acquisition of basic technical data for planning flood prevention measures. Also, that flood control engineering had acquired the status of a new distinctive branch with its own techniques and hence need for specialisation stressed. Training of personnel was recommended in subjects like (i) flood control planning, (ii) flood hydrology, (iii) flood control economics, (iv) meteorology and (v) hydro-meteorology in relation to flood forecasting and warning, (vi) electronic computer analysis, (vii) advanced instrumentation and communication, (viii) river bank stabilisation, (ix) soil conservation engineering, (x) debris control and (xi) land slide stabilisation. For this purpose, the Committee advocated training of personnel in large numbers in advanced countries like the USA, Japan and the Povalley, Italy. It also advocated training within the country. They also recommended introduction of flood control as a subject at graduate and post-graduate levels besides organising short-term refresher courses for serving engineers. As regards data acquisition, the Committee recommended the setting up of a basic network of hydrological stations, designed according to the latest scientific standards and equipped with suitable instruments so as to serve as key-gauging stations. This key-gauging network was to be drawn up by the Central Water Commission in consultation with the States. The Central Government was to bear the cost of some of the key-gauging stations located on inter-State or international rivers. The Committee also advocated training of professional and sub-professional personnel in scientific river gauging to be arranged by the Central Government. Also training in airphoto-interpretation was suggested for the personnel of the Flood Departments.

21.2.3. The Ministers' Committee on Floods and Flood Relief, 1972 recommended modernising of flood forecasting techniques, for obtaining reliable forecasts of floods well in advance. The

Committee suggested an appropriate meteorological set up with (a) an adequate network of rain gauges of measuring, recording and telemetering variety for the catchment area, (b) a reliable network of telecommunications for data transmission from rain-gauge stations to forecasting centres, (c) forecast facilities, (d) computational facilities for conversion of actual and forecast rainfall over the catchment into expected runoff and (e) a research unit for continuous updating computational procedures and forecast formulae and reviewing the results of the techniques developed.

In the field of flood warning the Committee, inter alia, recommended that once arrangements for flood warning were finalised for an area, the concerned public should be educated on the significance of the different types of warning and the action to be taken by them. Training in flood fighting was also advocated (a) for officers through refresher courses, and (b) for maintenance staff and home guards, in different methods as also through on-the-spot demonstrations. The Committee also suggested that technical notes on successful experience in flood fighting should be sent by the State after every flood season to the Central Water Commission for circulation in the country.

As a result of these recommendations, there now exists a chain of key-gauging stations on some of the important rivers and a reasonably good flood forecasting and warning system has been developed in recent years.

21.2.4. We, however, observe that all the recommendations made by the past Committees, have not been fully implemented. We, therefore, feel that in view of the recent advances made in the field of science and technology, much more emphasis needs to be laid on research, education and training as relevant to the subjects of water resources development, river training and control of floods.

21.3. **Global status of hydrology**

21.3.1. Hydrology is the basic requirement in all matters related to water. It scientifically examines the hydrologic cycle which largely influences agriculture, forestry, watershed management etc. Dependable hydrological data are essential for planning and design of hydraulic structures, water supply, sediment control, irrigation, drainage, hydro-power, or, flood control.

As the grand era of experimental hydrology, the 19th century ushered in the modernisation stage of hydrology when large constributions were made to ground water study and surface water measurements. However, the subject remained largely empirical upto 1930. During the next two decades, many eminent hydrologists came on the scene with rational analyses for hydrological problems instead of empirical formulae. In the early forties, use of the extreme-value distribution was adopted for frequency analysis of hydrologic data and use of statistics in hydrology re-emphasized. An outstanding development in this period was the establishment of many hydraulic and hydrologic laboratories as well as setting up of a number of National Resources Boards, Committees etc. throughout the world to deal with water. Sophisticated and high speed computers are now being increasingly used to monitor delicate hydrologic events and to solve complicated mathematical equations involved in the application of hydrologic theories. Many a rational hydrologic principle proposed by modern hydrologists can readily be subjected to mathematical analysis. The recent advances made in the field of fluid mechanics, unlike the traditional hydraulics, have promoted the development of theoretical hydrology. Such studies in theoretical hydrology include linear and non-linear analysis of hydrologic systems, transient and statistical concepts in ground water hydrodynamics, the sequential generation of hydrological data and above all the use of operations research in water resources system designs. These developments have generated many-fold activities to solve various kinds of water problems, mostly in developed countries. In the wake of these advances, the greater need for basic research and higher education in hydrology and water resources development has promoted many organisational expansions and programmes both on national and international scene. Judging by the advances made in the developed countries, much remains to be done in our country.

21.3.2. Recognising the role of water resources in human welfare, scientific research, education and training have drawn the attention of international organisations in order to optimise water utilisation and solve water problems. To promote co-ordinated efforts on water resources development and utilisation among member nations, a Water Resourcs Development Centre (WRDC) was set up in the United Nations Organisation (UNO) in 1959. Hydrologic studies relating to specific problems have also been encouraged by many of its organisation like the United Nations Educational, Scientific and Cultural Organisation (UNESCO), the World Meteorological Organisation (WMO)), and the Food and Agricultural Organisation (FAO).

In their global effort to co-ordinate development of research and training programmes in hydrology, UNESCO launched the International Hydrological Decade Programme during 1955—1974. The programme envisaged collaboration amongst the participating countries in the matter of developing hydrological research techniques, diffusing hydrological data, and planning hydrological installations. The programme also provided means for exchange of scientific views on hydrology amongst the participating countries.

India participated in this programme under the auspices of the Department of Science and Technology which provided the technical secretariat of the Indian Hydrological Decade Programme. Even after the termination of the Decade Programme in 1974, UNESCO continues international co-operation in the long-term programme of hydrology. Research organisations and institutions in the relevant fields of specialisation should collaborate in such international programmes.

21.4. Country status in research

21.4.1. Research activities have been accelerated in the post-Independence era when the country launched a massive development programme. With a view to achieve optimal efficiency and economy in the planning, design, construction and operation of water resources projects, major research stations have been set up under the Irrigation Departments of the States, except Haryana, Himachal Pradesh, Jammu & Kashmir and some of the States/Union Territories in the north-eastern region. There are also three central research organisations namely (i) Central Water & Power Research Station, Pune (1937), (ii) Central Soil and Material Research Station, New Delhi (1953-54), and (iii) National Institute of Hydrology, Roorkee (1978). In addition, research units on the subject are functioning in leading institutions like the Indian Institute of Science, Bangalore, Indian Institutes of Technology (Delhi, Kanpur, Kharagpur, Madras and Bombay), and in some universities and engineering colleges in the States. The Central Board of Irrigation and Power, consisting mainly of Chief Engineers of Centre and States dealing with the subjects of irrigation and power, as members, sponsores, co-ordinates and acts as the clearing house for research activities in the country.

21.5. Current research activities

21.5.1. (i) Central Water and Power Research Station, Pune, is functioning under the Central Government since 1937 when the Station was taken over from the Public Works Department of the erstwhile Bombay State. The Station with its 30 research and 6 service divisions, covers the subjects of hydraulics, hydraulic structures, earth sciences, ship model testing, coastal engineering, instrumentation and computer science. It undertakes prototype testing, digital data acquisition, investigations of turbine and pump models in cavitation tanks. Studies are also taken up for developing techniques for the use of radio-active and florescent tracers in tidal as well as fluvial flow conditions for various purposes. A 'Documentation Centre' at the Station as a part of the National Information System on Science and Technology (NISSAT) has been approved by a UNESCO mission which recommended United Nations Development Programme (UNDP) assistance of about $ 3,00,000 for the same. The High Level Committee which reviewed the functioning of the station has recommended its early establishment. Indeed, this will fill the long-felt need for such a 'Documentation Centre' at the national level to benefit the water resources development programmes in the country.

(ii) The Central Soil and Materials Research Station, New Delhi, conducts field and laboratory investigations for soil and material testing. Studies are also conducted in the fields of soil mechanics, rock mechanics, concrete technology, sediment investigations, pre-irrigation soil surveys and chemical analyses of construction materials as relevant to river valley and other projects.

(iii) The National Institute of Hydrology, Roorkee, has been set up in 1978 as a Society, registered under the Societies Registration Act, 1860. Its main objective is to undertake, aid, promote and co-ordinate systematic and scientific studies of fundamental nature in pure and applied hydrology. Through these efforts, the present practice of water development and budgeting are to be improved by the application of latest techniques. The Institute will also serve as the clearing house of information not only in regard to hydrological studies and research but also in hydrological matters in general. It is still in the initial stage of organisation and is likely to take some time before it can function as a full-fledged institute.

(iv) Irrigation Research Institute, Khagaul (Patna), Bihar, was set up in 1956. The station has done considerable work on soil, concrete and other construction material. It has also undertaken sedimentation survey of reservoirs and ground water problems.

(v) Gujarat Engineering Research Institute, Vadodara came into existence on the bifurcation of the erstwhile Bombay State. The research set up assumed its present name in 1960. The research projects undertaken at this Institute have contributed most to the ground water flow and its recharge, river training, sediment studies in canal and reservoirs, canal lining and material testing.

(vi) Karnataka Engineering Research Station, Krishnarajasagar, Karnataka was started as a material testing centre but was later strengthened and converted into a hydraulic research unit and assumed its present name in 1974. Studies conducted here have included prtotype behaviour of siphons under high heads. Other research projects include reducing evaporation, cheaper canal lining, sedimentation survey of reservoirs, problems of soil mechanics etc. In 1971, an engineering staff training college has been started at the station to impart in-service training to engineers of the Public Works Department by offering short and long-term refresher courses.

(vii) Kerala Engineering Research Institute, Peechi (Kerala), was set up in 1960. It carries out studies especially on the problems of sea-erosion and has evolved cheaper designs of sea walls for protecting the coast.

(viii) Centre for Water Resources, Development and Management, Trivandrum, Kerala has been established in 1978 as an autonomous multi-disciplinary body. The Centre plans to undertake advanced studies on all aspects of assessment, conservation, development and management of water resources in the State. The Centre will serve the 13 agro-climatic zones of the State through five regional stations, the main research station being located at its headquarters. It functions through 7 divisions namely (a) Education and Extension, (b) Economics and Statistics, (c) Surface Water, (d) Ground Water, (e) Water management (Agriculture), (f) Water Management (Industrial and Social Use) and (g) Water Quality and Environment. The Centre is meant to serve as the technical wing of all the Departments in the State concerned with water resources.

(ix) Irrigation Research Directorate, Bhopal, Madhya Pradesh was established in 1964. The research unit is mainly dealing with hydraulics, model prototype conformity problems, soil and material testing.

(x) Maharashtra Engineering Research Institute, Nasik, was set up in 1959 with a view to achieve efficiency and economy in the large water development projects. It carries out investigations on soil mechanics, material testing, hydro-dynamic problems, public health and rural engineering.

(xi) Hirakud Research Station, Hirakud, Orissa was established in 1947, during the planning of the Hirakud dam. It carried out testing of construction material for the project and observed the silt charge in the flow of the Mahanadi. In 1960 it got transferred along with the dam to the Government of Orissa which has since expanded its research activities to meet the needs of the State.

(xii) Land Reclamation, Irrigation and Power Research Institute, Amritsar, Punjab came into being after partition in 1947. The Institute was set up and the field research station at Malakpur in the district of Gurdaspur continued to handle the model studies for the control and training of rivers. The Institute serves as the zonal Institute for the North Zone, covering Himachal Pradesh, Jammu and Kashmir, Punjab and Rajasthan. A field lining research station has also been set up at Daburji (near Amritsar) for investigations relating to the economical specifications of lining material against seepage in the earthen channels.

(xiii) Irrigation Research Station, Jaipur (Rajasthan) was set up recently with a view to meet the research needs of the irrigation projects in the State and to use the local material for construction purposes. It is in the early stages of development.

(xiv) Institute of Hydraulics and Hydrology, Poondi (Tamil Nadu) was started as an irrigation research station in 1944. Its expanded activities include research relating to hydraulic problems of river valley and flood control projects in the State. The station became a fulfledged Institute of Hydraulics and Hydrology in 1973 which enabled it to cover the current activities on ground water hydrology, hydrology of river basins and flood prediction, hydrological modelling, instrumentation and watershed management schemes.

(xv) Uttar Pradesh Irrigation Reseach Institute, Roorkee, has been established in 1947 at Bahadarabad to meet the needs of Irrigation projects. The station got further expanded in 1955. It carries out both basic and applied research on problems in hydraulics soil mechanic, ground water, instrumentation, hydrology and measurements of discharges of rivers and canals. Investigations have also been taken up here on specific problems relating to river training and river protection works, soils and construction material. Hydraulic design of surge tanks for many major projects in Himalayan region and its computer simulation, design of gravel pack and prepacked filter for tubewells, design of barrages etc., have also been studied for use in the State.

(xvi) River Research Institute, West Bengal, Calcutta, was set up in 1943 to study various river problems of the State and to evolve measures for controlling causes of dying rivers. It specialises in river training and river conservancy, control of erosion and flooding, design of channels and meandering streams, conservation of tidal rivers etc.

(xvii) Indian Institutes of Technology: There are 5 Indian Institutes of Technology which were established by the Government of India with the specific objective of providing engineering and technological education at par with international standards of excellence. Their civil engineering departments have been doing a commendable job in the field of research, education and training in hydraulics, hydrology and allied subjects.

(xviii) The School of Hydrology, University of Roorkee (jointly sponsored by the Government of India, Ministry of Education and UNESCO) offers the international post-graduate course in hydrology since 1972. It caters to the needs of developing countries in Asia and Africa in offering advanced courses in the principles of scientific hydrology, and, analysis and use of hydrological data for integrated planning of water resources development.

(xix) The Water Resources Development Training Centre, Roorkee, has been established in 1955 in cooperation with US Technical Co-operation Mission and UN Technical assistance. The objective of the Centre has been to train serving engineers from Asia, Africa and other developing countries in different aspects of water resources engineering. It offers (i) a twelve months' training programme leading to a post-graduate diploma in Water Resources Development, (ii) a two-years course leading to a Master's degree in Water Resources Development, and (iii) a Doctor's degree in Water Resources Development.

(xx) Established in 1929, the Indian Council of Agricultural Research (ICAR) New Delhi, sponsors wide ranging research projects in the domain of agriculture through a country-wide research grid provided by 33 Research Institutes (Annexure 21.1), 54 all-India co-ordinated research projects and 21 Agricultural Universities in the States. Their research programmes, among others, include land and soil resources inventory, soil conservation and watershed hydrology, water management and agricultural drainage.

(xxi) The Forest Research Institute, Dehra Dun, set up in 1906 by the Government of India carries out research in all aspects of forestry including watershed hydrology for forest watersheds. Its silvicultural research continues to provide newer technology for afforestation and forest land management.

21.6. Research gaps and future research needs

21.6.1. *Rainfall—runoff*

It is felt that in the field of precipitation, more efforts are needed in items like time series analysis, stochastic modelling and Depth-Area-Duration (DAD) analysis of different storm events based on point data for the catchments of the most flood prone rivers, which lie in different geographical regions, across State boundaries.

With the latest advances made in electronics, it is now feasible to digitize the radar picture to obtain quantified information on rain-fall. A good network of radar is expected to be installed in the flood forecasting centres. Research and development efforts have, therefore, to be geared to achieve automatic use of radar information for hydrological work.

21.6.2. *Satellite and remote sensing technology*

This is the latest multi-purpose technology coming under increasing use in the flood sector. Our capability in the use of this technology is fast building up through the efforts of the Union Department of Space and the Department of Science and Technology, in collaboration with user agencies.

Apart from adequate education and trainin in the use of the technology, much more effort need to be made in research studies for groun truth vertifications and evolving appropriat field use of the modern technology. In the floo sector, remote sensing technology offers grea scope for use, specially where ground-based surveys prove inadequate in providing data ove large areas in short time.

21.6.3. The Television and Infra-Red Observation Satellite (TIROS) and its successor, the improved TIROS Operational System provides th principal Global Operational Meteorologica Satellite System. Weather pictures from thes satellites have found a permanent place amon the forecasters' tools. These have also provide new dimension in understanding the globa weather.

The first meteorological Satellite TIROS-1 wa launched by USA on April 1, 1960 and provided photographs of the earth and cloud formations These were followed by 9 additional TIRC Satellites during 1960 to 1965 and thereafter there have been continuous developments in the field all over the world, through developments of Polar Orbiting Satellites, Geo-Stationery Satellites, Nimbus Technology Satellites, Geo-stationery Technology Satellite and Operational Geo-stationery Satellite.

Geo-stationery Satellite has given a new dimension to satellite-meteorology which provided continuous monitoring facilities compared to instant observations of the polar orbiting satellite. With the introduction of multi-purpose Indian National Satellite (INSAT) system, the Indian Meteorological Department would enter into a new field of activity in satellite meteorology. The INSAT is expected to go into orbit in 1981. It will carry a pay-load for 3 distinct services namely, communication, meteorology and television. The meteorological payload will include (a) very High Resolution Radiometer and a Data Collection Transponder. It has been planned to have 100 land based and 10 ocean based data collection platforms. The Central Flood Forecasting Organisation has also planned to participate in the INSAT-1 programme, pertaining to collection of hydrological as well as hydro-meteorological data.

21.6.4. Remote Sensing technology helps data acquisition by the systems which are not in direct contract with the object or the phenomenon under investigation. Remote sensors installed in aircrafts and satellites react to the reflected and emitted electro-magnetic radiation from the earth's surface to produce images. These images, when analysed, yield a vast wealth of information to the resource-scientists and technologists. Airborne and space-borne sensors help collect data of interest to flood control and water resources planners in an effective time frame. Airborne surveys are known to have high ground resolution, and better control over data collection than that of satellite sensors, but are expensive with small area-coverage. Large area synoptic view is obtained by the satellite sensors though with a coarser resolution. However, they provide cheaper repetitive coverage of the same area though the time interval for the revisit may sometimes be too long. Passive sensors like camera, scanner, micro-wave radiometers etc., operating in the visible, beyond visible and in the longer micro-wave regions of the electro-magnetic spectrum can provide valuable data. Radar being an active sensor has the all-weather and all-day capability. While conventional black and white aerial photography provides valuable information, it is limited to visible spectrum only. Scanners, on the other hand, operate even beyond the visible spectrum to include near and middle infra-red regions. Thus, the multi-spectral nature of data from scanners provide for greater information on the flood producing catchments, the flood plain, the river and its morphology as also their response to the phenomenon of floods. The advent of 'Landsat' series of Earth Resources Satellite has given a rapid method of data collection over large areas. The Landsat-2 and 3 satellites are presently providing global coverage with the same area covered repetitively once every 9 days.

21.6.5. In the flood sector, flood inundation mapping serves many purposes. Apart from showing the aerial spread of flood affected areas, it identifies areas needing post-flood alleviative measures. It also brings out the effectiveness of flood control works and their effect on river flow, which information can be used for further planning, strengthening or additional measures/works. Quantitative information on basin geo-morphology can also be obtained in much less time and thus help to develop flood forecast models, which are gaining popularity. The usual hydrological approaches for flood prediction involves simulation by computer and regional extension of existing records in space. While simulation models have achieved some success, they do not explain runoff generation. The more logical alternative would be a model that relates geo-morphic processes to the resulting runoff. Elsewhere in the world many studies have attempted quantification of basin geo-morphology from remote sensed data. A number of watershed models have been formulated to obtain information on the watershed processes and functioning between the precipitation (input) and river runoff (output), which are dependent upon the basin characters like land use, surface cover, stream length and order, drainage density, area, shape and slopes of the basin, stream gradient etc. Remote sensing from space borne or airborne sensors can provide required information on the uptodate basin character, specially of inaccessible areas with much less time and cost as compared to conventional means. This opens up new vistas for runoff prediction from ungauged watersheds in our country.

We recommend that further studies should be carried out towards developing watershed models suitable for using remotely sensed information as inputs, in order to predict flood flow under inadequate or no data situations.

21.6.6. Information through satellite offers great scope for flood warning. The earth orbiting satellites like 'Landsat' series or the geostationery satellites have on board a data collection system (DCS) which transmits data received from ground-based Data Collection Platforms (DCP) to the computer managed control data processing facility. The most common hydrologic variables, such as precipitation, snow water equivalent, water stage, stream flow, etc. can be inter-faced with the data collection platforms. Ground derived hydrologic data from far-flung and inaccessible areas can be relayed *via* satellite to the water resources management centre within a fraction of a second and many times each day. The ready availability of the data from widely dispersed locations at speed and less cost, has given a filip to the flood warning system so desparately needed during the critical periods of flood. These data are also vital for efficient reservoir operation, flood warning to flood plain dwellers and timely action for emergency measures, if any. The satellite based data collection system gains added importance because of inter-State riparian problems and the inter-State nature of our major flood-prone river systems.

Appreciating these advantages, we recommend that, as a first step, pilot studies should be undertaken on the use of remotely sensed data for a few basins/sub-basins of a couple of inter-state flood prone rivers. Timely arrangements should also be made for training of the multi-disciplinary personnel, which may be needed for these studies.

21.6.7. Flood mapping through active micro-wave sensing needs consideration because of its all-day capability. A step in this direction has already been taken by the Kosi Project Authorities when they requested the National Remote Sensing Agency (NRSA) in January 1978 to conduct the airborne scanner survey of the Kosi flood plain and provide information on the effectiveness of the flood control works on the flow pattern of the rivers. Encouraged by the valuable information obtained by this survey another survey was also sponsored by the State of Bihar which was carried out in October 1978. In view of the chronic problem of flood in the Brahmaputra valley, the North-Eastern Council has also sponsored an airborne scanner survey of the flood plain, lying along the Brahmaputra main stem. The scanner survey was done in November-December 1978, covering an area of 12,000 sq. km. It is also proposed to conduct repetitive surveys over the next five years to study river migration and flood plain characteristics which will eventually provide the inputs to a comprehensive plan for developing this case. We feel that the usefulness of the scanner survey for flood plain maping should be assessed and encouraged if found effective:

21.6.8 *Small dam technology*

Elsewhere in the report, we have dealt with the importance of watershed management for sediment control and flood mitigation. Units of 2000-4000 ha small agricultural watersheds have been proposed for launching an action programme of watershed management in selected flood-prone river basins. In this campaign, apart from other soil and water conservation measures, small reservoirs and farm ponds will form part of the programme for flood moderation. It envisages construction of numerous small dams with suitable spillways to suit varying soil-climatic conditions under monsoonic pattern of rainfall. So far most of our research efforts have been oriented towards high dams. However not enough research studies have been carried out in the small dam technology to offer economic design specifications under different soil climatic conditions. In the wake of the intensified rural development programmes, watershed management programmes for flood mitigation would fit in eminently and increasing demand from the block administration in the flood prone basins would be expected for prescribing appropriate specifications for those small hydraulic structures.

We therefore recommend that appropriate research studies on prototype performances of check dams, small detention reservoirs and the like as relevant to the watershed management programme, should be undertaken in order to develop technical manuals for the various soil-climatic regions.

21.6.9 *Instrumentation Research*

In order to measure the various meteorological and hydrological parameters, like rainfall, water levels, discharge, seepage, sediment charge, etc. various types of instruments are required. Instruments are also required for monitoring the behaviour and functioning of major hydraulic structures and for seismic surveillence in the vicinity of these structures. It is, therefore, necessary to indigenously develop and manufacture the required instruments. Some work has been done in the Instrumentation Division of the India Meteorological Department and the Central Water & Power Research Station, Pune, but a lot yet remains to be done in this field. We therefore recommend intensification of research, and later development and production of the proven instruments.

21.6.10. *Watershed research*

Experimental studies on watershed basis have been the approach in determining the hydrological consequences of major changes in land use. The studies undertaken in the representative watersheds (basins/sub-basins) and experimental watersheds (less than 2000 ha) in the world have generated a good deal of field data to determine the influence of different watershed characters, individually and in combination on basin hydrology under a variety of conditions. In our monsoonic conditions, the river flow is known to vary widely with the variation in the seasonal and annual precipitation. Hence long term flow data are required in order to typify the river behaviour.

Effect of land use on river flow has been studied elsewhere in the world by long-term comparisons. Hydrological studies in experimental watersheds were initiated in our country in early sixties, when small agricultural and forest watersheds were gauged by the soil conservation research centres and the Forest Research Institute, Dehra Dun. These small experimental watersheds still continue to be under study mostly with the help of imported automatic gauging instruments for stream flow and automatic rainfall recorders. However, as the automatic instruments of dependable quality in adequate numbers are not readily available locally, the experimental watershed studies in the country have not expanded. Recently the Central Water Commission has initiated hydrological studies in small catchments. In pursuance to the recommendations of the Khosla Committee of Engineers, a Directorate of Hydrology (Small Catchments) has been created to carry out research and analysis of river flow data in Railway and Road Bridge catchments in different regions of the country. Under the long-term plan of the Directorate, a chain of representatives basins and experimental watersheds is to be set up in various hydro-meteorological, zones of the country for systematic acquisition of hydrological, meteorological and topographical data. These are good beginnings but the research efforts in watershed hydrology has to be intensified many-fold. In recognition of the complex and long-term nature of the watershed research, we recommend that (i) the scientific plans of these research projects should be carefully drawn up in detail after identifying the suitable watersheds to represent major soil-climatic zones in the country and (ii) in the first phase these studies should be conducted in at least a few experimental and representative watersheds of the major flood-prone rivers.

21.6.11. *River science and river engineering*

Research in river science and river engineering have been in progress for a long time. However, much progress has yet to be made in this sector. So far researchers on the subject have confined their efforts mostly to model experiments in determining location, spacing, lengths of spurs or other river training works, and in a limited manner to obtain flow pattern, flood levels etc. in post-embanked conditions. It is known that model experiments alone do not take us far in understanding the behaviour of our rivers which with their individual characters, pose different problems. It, however, appears that no systematic effort has been made for collection of scientific data on river behaviour and its response to many man-made structures, encroachments etc. in the flow channel or the flood plain. The river morphology and the flood flow in the channel should be studied scientifically in order to plan flood control and river training works as also water utilisation projects.

Such studies are very important, particularly for the flood prone rivers. It is for example known that at times embankments raise the river bed, create waterlogging behind the embankment deny the farmers the flood benefits of abundant moisture and silt, cause many-fold devastation when they breach etc. Since flood control efforts so far have been mainly confined to the construction of flood embankments it is considered necessary to take up scientific studies to determine with data base the precise effects of embankments on the river channel and flood plain

Permanent structures as well as age-old temporary cultivation of river beds are often mentioned as encroachments, causing interference with river hydraulics. Unfortunately, there has been no significant study in evidence to determine scientifically the precise extent of hydraulic interference caused by these practices. Since flood plain zoning is being contemplated in our country it is essential that suitable studies should be taken up to precisely determine the influence of different kinds of encroachments in the flow channel and flood plain to facilitate enforcing land use regulation.

We therefore recommend that research studies in the field of river morphology and river response to various structures, used in river training and flood prevention works as also to encroachments should be intensified.

21.6.12 *Drainage*

Till recently, drainage has been largely a neglected aspect of agriculture and irrigation practices. However, since the late sixties, some awareness has been shown in various research stations and agricultural colleges and universities in respect of drainage systems. In order to improve the norms and design criteria, a lot of work, however, yet remains to be done. We therefore recommend that scientific studies should be taken up (i) to determine values of hydraulic conductivity, rate of water table fluctuations and intake rates under different soil conditions, self clearing velocities in drains and drainage indices for the different regions of the country, and (ii) to obtain information on the crop response to different periods of submergence with different depths, both under stagnant and flowing water conditions, as well as with different concentration of soluble salt content of ground water and turbidity.

21.6.13 *System analysis and water resources management*

During the past two decades, lot of progress has been made in the field of mathematical modelling techniques and computer technology as applied to woter resources systems most of it has, however, been in the academic field and commensurate advance in their applications to water resources planning and decision making in our country is still lacking. The use of multi-disciplinary mathematical models is the best technique which enables a more incisive insight into the consequences of the possible alternative decisions in solving water resources problems. It is, therefore, recommended that research in and use of mathematical modelling be encouraged.

21.6.14. *Glaciers and snow pack*

There is an increasing interest in scientific studies to determine the contribution of glacier and snow-melt to flood flows in the Himalayan rivers. In view of its importance, some studies in the Himalayan glaciers have been initiated by the Geological Survey of India, the IMD and individual scientists.

We, therefore, recommend that efforts should be intensified towards scientific surveys and investigations on snow and glacier melt and determination of their contribution to floods in the Himalayan rivers.

21.6.15 *Water quality observations*

In the wake of industrialisation and urbanisation there is a noticeable increase in pollution of our water bodies. Uncontrolled dumping of waste in rivers is the basic cause of water pollution. Study and research on a continuing basis are necessary in order to develop a system approach for maintaining and enhancing water quality. Research is also necessary in respect of the ill effects of water pollution on structural materials of engineering works. As such it is recommended that research should be intensified to ascertain the effects of water pollution on such structural materials works and to evolve methods to maintain water quality.

21.6.16 *Reservoir sedimentation*

One of the most important problems in the design, operation and maintenance of storage reservoirs is the loss of storage capacity due to silting resulting from the deposition of stream borne sediments. Actual field surveys under the aegis of the Central Board of Irrigation and Power have been taken in hand on a number of reservoirs. We recommend extension of the programme and fixation of norms to assess, more precisely, the pattern of siltation and the life of reservoirs in various parts of the country.

21.6.17. *Aquatic weeds*

Aquatic weeds in the reservoirs are responsible for the loss of some storage due to transpiration of large quantity of water. Further, with their dense growth, these aquatic weeds seriously interfere with the flow of drainage courses. Quantitative information regarding their effects on loss of water in storage and interference with the flow conditions is lacking. We therefore recommend that suitable research work should be undertaken not only to determine the quantitative effect on the storage by these weeds but also to find out ways and means for the eradication of weed growth in reservoirs and natural and artificial drainage channels.

21.6.18. *Hydro-geology ground-water geophysics and ground-water engineering*

Technical studies and research are needed to establish a standardised methodology for correctly estimating the hydrological equation between discharge and recharge in ground water reservoirs. In a number of areas, due to excessive exploitation, there has been progressive depletion in the ground water reservoirs and water levels have shown a progressive lowering. The possibility of artificially recharging such areas with flood water have to be explored in sufficient detail to establish methodology and to evaluate the extent of success which can be achieved. Recognising its importance in a programme for flood mitigation we advocate that research should be taken up not only to identify suitable recharge areas but also evolving a suitable methodology for recharging on an operational scale.

21.6.19. *Construction materials*

Soil, concrete and masonry are the main materials in extensive use in the construction of dams, embankments and other hydraulic structures for water resources development and utilisation. Recognising the importance for economical utilisation of these materials, a number of problems have been identified for research and development which is in progress in various research stations of the country. In our view, however, it is further necessary that research on newer items of materials used in river training like reingorcer earth, fibre reinforced concrete etc. should be undertaken.

21.6.20. *Flood forecasting*

In the long-range plan of flood protection and prevention of flood damages, flood forecasting services assume considerable importance not only in the unprotected but also in the protected areas. The Central Flood Forecasting Organisation has developed several empirical, mathematical and conceptual models for forecasting floods in the flood prone regions of the country. It has also taken up several schemes of modernisation of flood forecasting system through UNDP assisted scheme for the Yamuna basin, participation in Satellite for Earth Observation Programme, participation in INSAT programme, strengthening and automation of data collection base and use of computer forecast formulations. Continuous research and studies are also needed for development of rainfall-runoff relation particularly for smaller catchments where flash floods occur, improvement in the techniques of network design of raingauge stations. A pilot study of a fully automated flood forecasting system should be taken up in a selected flood-prone basin/sub-basin. Further intensification of efforts for refinement of present techniques and providing a countrywide coverage of the programme is advocated.

21.6.21. *Agricultural research relevant to flood*

During floods, the standing crop is damaged due to muddy water submergence. The extent of such damage varies according to the depth and duration of submergence as also the nature of Khariff crop in the field. Not enough research is in evidence to quantify the extent of flood damage caused to crops by such submergence. There is a practice of 'Uttera' crop in the chronically flood affected flood plains, 'Tals' etc. Farmers sow germinated seeds of pulse crops in the slush as the flood water recedes without any preliminary tillage. As one gets less time to prepare the soil which is often heavy in texture, 'Uttera' practice is popular in the chronically flood-prone areas. No study is in evidence to refine this practice and appropriate research should be undertaken by the local agricultural universities.

We have earlier indicated the research needs of flood-prone areas in the field of crop improvement, agronomy and alternate land use systems. A special emphasis is laid on developing more of flood resistant or escaping crop varities as well as improving the deep water paddy. We reiterate that (i) agricultural research on the problems of the chronically flood-prone areas to improve production be intensified, (ii) suitable pilot operational projects to establish the economic feasibility of the proposed 'Range-Feedlot' system of cattle management be undertaken and (iii) pilot studies on river bank plantations against sandcasting and bank erosion should be taken up.

21.6.22. *Techno-economic research*

Modern approaches and techniques are available to evaluate existing and newer technology for their cost effectiveness and for finding alternatives. Researchers need to be exposed to such evaluation on continued basis, in order to promote development of appropriate technology.

Presently there exists a lag in this area of techno-economic evaluation of technology. Further, no techno-economic evaluation of projects executed in the flood sectors has yet been taken up to assess the technical efficacy of the measures adopted and the benefits actually realised from them in the field as against those envisaged in the projects. In view of the importance, we recommend that steps should be taken to provide suitable units, staffed with qualified economists in the departments and research organisations concerned with water resources development and water problems, for undertaking techno-economic research on (i) the existing and newer technology to tackle the flood problem and (ii) methodology for quantifying indirect damages and indirect benefits. Similar studies should also be sponsored in the local agricultural universities and selected economic institutes.

21.7. Research infrastructure and personnel policy

21.7.1. As discussed, earlier, there is already a network of research infrastructure in the form of Central and State Research Institutes/Centres/Stations to undertake research relevant to development and regulation of our water resources. These research organisations are variously staffed. While in some of the central research organisations some of the research and scientific personnel are borne on a research cadre, others are taken on deputation. In the States the research and executive staff are usually borne on a common cadre. Project experience being counted essential for the service engineer in earning his career promotion, the research engineer of repute often shifts to fill a higher managerial posts. Hence the present personnel policy does not appear to be conducive to staff continuity and specialisation in research.

21.7.2. The research gaps and the need in the water resources' sector as dealt with earlier demand specialised research efforts to be undertaken by well qualified specialists on continued basis. If the desired results are to be achieved in those areas within a given timeframe, the existing research infra-structure in the country has to be suitably strengthened with required research facilities and adequately staffed with well trained specialists, borne on attractive payscales. This calls for a country wide review of the research organisations dealing with water resources development and water problems. Pending such a national review of the research organisations engaged in water resources development and problems we recommend intensification of research efforts in the lines indicated earlier by suitably strengthening the existing research organisations with adequate research facilities and required specialist staff as also providing attractive research allowances.

Further we recommend that in due course, the National Institute of Hydrology should be allowed to grow and expand its research activities by setting up 4 Regional Research Institutes one each for (1) the lower Ganga basin; (ii) the Brahmaputra basin, (iii) the basins of the major east kowing rivers, and (iv) the basinc of the important west flowing rivers.

21.8. Education and training

21.8.1. The custodians of the country's technical education maintain a continuous review for harnessing science and technology in the service of human welfare. This becomes evident from the many specialised postgraduate courses which are offered now more than ever before in the technological institutes and colleges in the country. However, standard of technical education and training in the field of water resources development has yet to attain a level at par with those of some of the advanced countries.

21.8.2. In planning the best utilisation of the available water resources, the need for the services of competent hydrologists is felt more now than ever before. So far, graduates in civil engineering, by and large, constitute the professonal staff manning all programmes and projects in water resources development and water problems, from project investigation and planning to implementation as well as connected research. As on joining a government department, a graduate civil engineer is required to undertake various types of civil engineering works; accordingly the present undergraduate course covers the field of civil engineering in a general way. In the present day context, however, there is need for specialisation. In the matter of water resources planning and flood control specific orientation, amongst others, in the subject of hydrology, hydraulics, flood engineering, watershed management etc., is helpful.

We, therefore, recommend that (i) a number of elective programmes should be suitably included in the relevant curricula at the undergraduate level to produce more graduate engineers with a bias for water resources planning, hydrology, flood etc. and (ii) high level specialised courses should be offered in all aspects of hydrology, water resources planning and management, leading to post-graduate degree or diploma at a few selected centres like the Indian Institutes of Technology, engineering universities and engineering colleges, where adequate facilities exist.

21.9. In-service training

21.9.1. With a view to keep up with the recent advances and modern developments made in different areas of specialisation, in-service training of serving engineers and scientific personnel is considered important. In recognition, the Central Water Commission organises short duration refresher courses for Central and State Government engineers on important subjects. Appreciating its importance we recommend that more of short duration refresher courses should be included in the programme covering comprehensive planning for flood mitigation, flood hydrology, watershed management, flood economics, remote-sensing technology, hydro-meteorology for flood forecasting and warning, flood fighting, advanced instrumentation and communication, computer analysis, river bank stabilisation etc. The Central and the State Departments should avail of these refreshers' courses by deputing increasing number of participants. They should also liberally sponsor training and study tours abroad for the specialist staff to acquaint them with the recent advances made in science and technology.

21.9.2. There are leading institutions like Indian Institutes of Technology, School of Hydrology, University of Roorkee, Water Resources Development Training Centre, Rookee, where specialised courses of training are offered in the subjects of water resources development and related topics. It is, therefore, recommended that Central and State Departments should avail of such specialised training programmes by sponsoring professional personnel in increasing numbers.

21.9.3. Training of maintenance staff is considered important and has been emphasised from time to time. The concerned staff should be fully conversant with the maintenance manuals and the administrative instructions issued in this behalf. Apart from holding national level workshops and seminars at intervals on maintenance to apprise the State officials with the national guidelines on the subject, we advocate that the State departments should organise annual training camps for their maintenance staff with a view to update them through on-the-spot demonstration of various methods of maintenance.

21.10. Peoples' training

21.10.1. Training of land users is very helpful in the general drive for better land use, watershed management, optimum utilisation of water resources and minimising water problems. A conscious public contributes most towards the success of any developmental programme, and in the flood sector they help organising land use adjustment, land use regulation, flood warning, flood fighting, rescue and relief, post-flood rehabilitation works etc. The land user and the public at large should be aware of the extension programmes in operation in the locality for the welfare of the individual and the community. In recognition we recommend that suitable training camps 'Barh Vigyan Kendras' should be organised where training to land users is imparted through action programmes, visuals, and other training aids on the above subjects.

21.10.2. Field training programmes and camps for students are acknowledged pathways to make youth programmes creative and productive. Scout activities, the National Cadet Corps programmes and the like can profitably contribute to rural landscaping, tree planting, clearing aquatic weeds from drainage courses, building small storage structures on streams, community watershed management programmes etc., while imparting them practical experience in technology. Similarly the educated youth in the flood plain should be trained in flood fighting, relief and rehabilitation measures so that well trained young volunteers are readily available in the flood-prone rural areas to assist the local administration in fighting flood when it occurs. Hence we recommend that the country's youth programme in operation should also embrace such items which promote rational land use, optimum utilisation of local water resources and flood moderation.

ANNEXURE 21·1

Ref. Para 21·5·1 (xx)

List of Research Institutes of the Indian Council of Agricultural Research (ICAR)

State/Union Territory	Name of the Research Institute (ICAR)
Andhra Pradesh	1. National Academy of Agricultural Research Management, Hyderabad.
	2. Central Tobacco Research Institute, Rajamundry.
Bihar	3. Indian Lac Research Institute, Ranchi.
Haryana	4. Central Soil Salinity Institute, Karnal.
	5. National Dairy Research Institute, Karnal.
Himachal Pradesh	6. Central Potato Research Institute, Simla.
Karnataka	7. Indian Institute of Horticultural Research, Bangalore.
Kerala	8 Central Plantation Crop Research Institute, Kasergod.
	9. Central Tuber Crops Research Institute, Trivandrum.
	10. Central Marine Fisheries Research Institute, Cochin.
	11. Central Institute of Fisheries Technology, Cochin.
Madhya Pradesh	12. Central Institute of Agricultural Engineering, Bhopal.
Maharashtra	13. National Bureau of Soil Survey and Land Use Planning, Nagpur.
	14. Central Institute for Cotton Research, Nagpur.
	15. Cotton Technological Research Institute, Bombay.
	16. Central Institute of Fisheries Education, Bombay.
Meghalaya	17. ICAR Research Complex for North Eastern Hill Region, Shillong.
Orissa	18. Central Rice Research Institute, Cuttack.
Rajasthan	19. Central Sheep and Wool Research Institute, Avikanagar.
	20. Central Arid Zone Research Institute, Jodhpur.
Tamil Nadu	21. Sugarcane Breeding Institute, Coimbatore.
Uttar Pradesh	22. Central Soil and Water Conservation Research and Training Institute, Dehradun.
	23. Indian Institute of Sugarcane Research, Lucknow.
	24. Indian Veterinary Research Institute, Izatnagar.
	25. Vivekanand Parvatiya Krishi Research Shala, Almora.
	26. Indian Grassland and Fodder Research Institute, Jhansi.
West Bengal	27. Jute Technological Research Laboratory, Calcutta.
	28. Central Inland Fisheries Research Institute, Calcutta.
	29. Jute Agricultural Research Institute, Calcutta.
Delhi (UT)	30. Indian Agricultural Research Institute, New Delhi.
	31. Indian Agricultural Statistics Research Institute, New Delhi.
	32. National Bureau of Plant Resources, New Delhi.
Andamans	33. Central Agricultural Research Institute for Andaman and Nicobar Group of Islands, Port Blair.

XXII CYCLONES AND SEA EROSION

22.1. Introduction

Cyclones and Sea Erosion are not included in the Terms of Reference of the Ayog. However, during the visits of the Ayog, some of the coastal States put forth a plea that these problems be also considered along with the problem of floods. We have, accordingly, thought it fit to briefly deal with the subject.

CYCLONES

22.2. Tropical cyclones

Tropical cyclones, hurricanes and typhoons are regional names for what is essentially one and the same phenomenon. Depressions in the tropics which develop into storms are called tropical cyclones in the South-West Indian Ocean, in the Bay of Bengal and Arabian Sea, in parts of the South Pacific and along the northern coasts of Australia. These storms are called typhoons in the North-West Pacific, and are known as hurricanes in the Carribean, in the South-east of the USA and in Central America.

The term 'CYCLONE' is derived from the Greek word kukloma meaning the coil of a snake. When fully developed, a cyclone is a vast whirlwind of extraordinary violence 150 to 800 km across and 10 to 17 km high spiralling around a centre and progressing along the surface of the sea at a rate of 300 to 500 km a day. The speed of wind within 50 to 100 km of the centre in a mature storm, can be 160 km per hour or more. The winds associated with such storms are among the most violent and the rainfall accompanying them, is always very heavy. All that modern science has accomplished in dealing with cyclones is that the velocities of the wind and the rainfall that accompany these winds can be determined and their movement forecast to a certain degree.

A vast whirlwind of enormous power, the cyclonic storm transfers its whirling movements to the sea water, and, since the storm itself moves comparatively slowly, the winds act for a long time on the water surface producing strong currents of water up to depths of 20 to 25 metres. When the storm approaches a coastal belt, the sea level rises, rather suddenly to an overwhelming extent causing dangerous inundations over the coastal areas. The sudden rise in the sea level associated with cyclonic storms is called storm tide or tidal wave. When these storm tides strike the coast, they can cause large scale devastation in a matter of minutes. In India, cyclonic disturbances of varying intensities and extent originate in the Bay of Bengal and the Arabian Sea mainly during the period April to December. The number of storms occuring in the Bay of Bengal is on an average 4 to 5 times more than that occurring over the Arabian sea. The storm which form in this region during the transition months of April to May and October to November are of great intensity having an inner core of fierce winds. The cyclonic disturbances of the monsoon season (June to September) known as "monsoon depressions", are as a rule, of smaller intensity. They form at the head of the Bay and follow a north westerly course and the damages caused by them are mainly due to heavy rain rather than due to strong winds. October and November are the two months to be dreaded most as regards cyclones originating both in the Bay of Bengal and the Arabian sea, the exception being 1979 when there was a fairly severe cyclone in May that struck the coast of Andhra Pradesh. In general, the meteorologists feel that the post and pre-monsoon cyclones usually unleash all their fury on striking the coast and collapse soon after. But the monsoon cyclones possess the unique capacity of travelling without collapsing, on both water and land surfaces. The monsoon depressions, in general, yield copious rain along their tracks, as they move across the country.

22.3. Damage by cyclones

In its combination of violence, duration and size of areas affected, the tropical cyclones appears to be unrivalled, amongst all the natural phenomena, for the sum total of destruction it can cause.

Though the life span of cyclonic storms passing over the coast of India does not exceed 3 to 6 days the devastation caused is phenomenally high. Extensive damages are caused on account of the strong winds that blow up to 160 km per hour, heavy rainfall of, sometimes, as much as 25 cm in 12 hours and the gigantic tidal waves of 5 to 6 metres that roll over the coastal belt of 20 to 30 km. The winds uproot innumerable trees and cause serious damage to hutments, public buildings, engineering works, telephone and power lines and standing crops. The rain causes inundation and drainage congestion that paralyses human activity apart from damaging crop and property in places which are not normally affected by river floods. The sea floods engulf all that comes in their way, leaving only mute remnants of pucca buildings and lives that could seek shelter in upper storeys or on high ground. The comulative effects of these tremendous forces are loss of thousands of human lives, lakhs of cattle and livestock, washing away of complete villages, damage to standing crops in lakhs of hectares, flooding and water logging in low lying lands over vast stretches, salinity of soil in thousands of sq. kms, sand casting in extensive areas and damage to private and Government property and public utilities like Railway lines, arterial and feeder roads, power and communication lines, water supply, etc. An idea of the enormity of loss sustained during such cyclones can be had from the 1977 cyclone in Andhra Pradesh which took a toll of 30,000 human lives and caused damages to property of the order of Rs. 336 crores. These figures do not reflect the human misery suffered and the set-back to developmental works.

22.4.1. *The extent*

Cyclones are experienced by the coastal States of the Arabian sea and the Bay of Bengal. The effects have been always more pronounced in the States located on the coast of the Bay of Bengal, namely West Bengal, Orissa, Andhra Pradesh and Tamil Nadu. Past experience indicates that Andhra Pradesh has suffered the maximum.

22.4.2. *Andhra Pradesh*

Cyclones of varying intensity have been recorded in the State during the past four centuries. On October 13, 1697, a massive cyclone hit Masulipattinam and the neighbouring areas killing about 20,000 people. A dreadful cyclone rolled in the region of Ingeran in the East Godavari district on May 20, 1787 killing about 12,000 people and causing terrible devastation in the countryside. In December, 1789, a tidal wave swept the town of Coringa, apparently during a cyclone. According to the manual of the administration of the Madras Presidency, 20,000 people perished. A severe cyclone battered the East Godavari district on May 10, 1832, and, again in 1839 when over 30,000 people were killed. An eye witness has recorded, "The number of vessels of 100 to 200 tons that were high and dry miles inland, some bottoms up, gave the country the appearance of having been visited by a party of gigantic demons who had been throwing huge hulls at one another."

One of the worst cyclones in history overwhelmed Masulipattinam on November 1, 1864. It was associated with storm surge about 4 metres high which affected 128 km. of the coast and penetrated 27 km. inland. Recently in 1969, Andhra Pradesh was ravaged by cyclones, one of May 17 and the other of November 7 to 8. Both of them caused considerable loss—Rs. 20 crores in May and Rs. 65 crores in November.

The worst tragedy, however, was caused by the cyclone of November 19, 1977, which was rightly termed, "A national calamity". The cyclonic storm hit the 5 coastal district of Krishna, Guntur, Prakasam, West Godavari and East Godavari. A tidal wave of unprecedented nature almost 5 metres high, hit the taluqs of Divi and Bandar of Krishna district. The winds attained a velocity of 150 km. per hour. The tidal wave which rose to a height of 6 metres rushed towards the coastal cultivable lands up to 16 km. in length. The weather office described the cyclone as a wide eyed storm with a radious of nearly 40 km. and reported that the northern periphery of the eye of the storm hit the coast. The coastal belt of about 400 km. between Ongole and Kakinada bore the brunt of the storm. Starting on the afternoon of the 19th November, 1977, it continued up to midnight. There was heavy rain (25 cm.) during the period of the cyclone and most of the low lying areas were inundated. The standing rain water acted as a buffer between the salt water of the tidal wave and the soil and saved the soils from becoming saline.

Great damage was caused to life and property of the inhabitants in the cyclone-affected area. About 30-50 lakhs persons were rendered homeless, 60 villages were completely washed away and some 10,000 people were estimated to have lost their lives. Also, about 2.36 lakhs heads of cattle and 1.57 lakhs of other livestock were killed. The total loss of crops was estimated at Rs. 336.37 crores. This does not include loss to Government property like Railways, telephone communication lines, roads, etc.

During 1979, there was a severe cyclone on the 12th of May. The damage to lives was only about 600. But the irony was that some areas which were affected in 1977 received a second battering. The damage to Railway property alone was Rs. 3 crores, and the entire Railway communication with the southern part of the country was dislocated for more than 3 weeks. The main difference between the 1977 and the 1979 cyclones was that in 1979, there was killer tidal wave. Another difference was that in 1979, the fields in Krishna district were damaged by sand deposits whereas in 1977, it was salt deposit. The total damage was estimated at Rs. 205 crores in Prakasam district and Rs. 4.5 crores in the Nellore district. Livestock losses were estimated as 2,00,000 in Nellore and 1,35,000 in Prakasam districts. In Kanigiri taluq of Prakasam district, rainfall recorded in 6 hours was about 44 cm. which is the normal figure for the whole year. In other places rainfall was of the order of 20 cm. with wind speed of 150 kmph.

22.4.3. *Orissa*

In the recent past, severe cyclonic storms have been reported in November, 1942, October, 1967, October, 1968 and the historic severe cyclone of October, 1971. There have been minor cyclones during other years. In Orissa, the cyclones are usually experienced in the months of October and November. At this time, the Kharif paddy is generally in the flowering stage. The flowers being blown off by strong winds, damage the paddy crops seriously. Also, as in Andhra Pradesh, trees are uprooted, kutcha houses are blown away, many pucca buildings collapse and there is loss of life—human and cattle—and property. The very economic structure is hit when a cyclone strikes the coastal districts.

The coastal districts affected frequently are Ganjam, Puri, Cuttack, Balasore and Mayurbhanj. The fertile land affected is up to an extent of 25 km. inland. 75 per cent of the people in this area depend on agriculture and 5 per cent on fishing. About 90 per cent of the population live in thatched-roof houses. The communication system of the area is extremely poor. The weaker section of the society in Orissa is not able to improve their economic condition on account of frequent floods, saline inundation and severe cyclones.

The intensity of the cyclone that swept over the coast during October 1971 and which was one of the worst in living memory cannot be fully understood on account of limited observation points along the coast in this region. The maximum wind speed attained has been reported to be 163 km. per hour, the maximum wave height about 5.6 m. though the tidal surge experienced in different places has been noted to be of the order of 3 to 4 m. Another problem in this region is the presence of a number of inlets into sea which allow the tidal waters to be driven inland for considerable distances causing damage on both the sides of the creeks.

22.4.4. *Tamilnadu*

The coast of Tamilnadu has been hit by cyclonic storms with disastrous effects 35 times since 1900, that is, almost once in two years. In some years, the coast has been hit more than once. The districts affected by cyclones in the State are, Kanyakumari, Thirunelveli, Ramanathapuram, Thanjavur, South Arcot and Chengalpattu.

The cyclone that hit Nagapattinam in Thanjavur district on 30-11-52 took a toll of 400 lives and thousands of cattle. On 1-12-1955, Rajamadam in Thanjavur district was invaded by a tidal wave all along the 25 to 30 km of the coast resulting in the loss of 500 human lives, a lakh of cattle, heavy damage to property and a recession of land to the extent of 200 yds. (182.9 m). In November, 1964, Madras experienced a severe cyclone in which 30,000 people were rendered homeless, besides loss of some lives. Again on 23-12-1964, in Thondi near Dhanushkoti and Rameswaram island, the Mandapam Railway bridge was washed away and 900 lives were lost. In November, 1966, Madras harbour suffered heavy losses resulting in splitting of a ship involving the death of 26 crew members and 19 people on the main land. The Vidur reservoir breached and 11,42,000 huts, 2,800 irrigation tanks and several anicuts and channels were damaged.

There have been damage-producing cyclones (i) in 1967 at Rameswaram, (ii) in 1969 at south of Madras, (iii) in 1972 near Cuddalore, (iv) in 1975 near Madras, and (v) in 1976 at Madras and Chengalpattu districts. The year 1977 witnessed cyclones both in October and in November causing damage in Ramanathapuram district in October and a wide area in the districts of Ramnad, Thanjavur, South Arcot, Thiruchirappalli and Madurai during November. 560 lives were lost apart from 196 who were reported missing. Several thousands hectares of paddy fields and extensive areas of millet, sugarcane, betel-vine and coconut topes were damaged. Innumerable villages were marooned due to heavy floods in the Kavari, the Coleroon, the Vellur, the Kodaganal, and even big towns like Thiruchirappalli, Srirangam and Karur, were threatened. There was total disruption of communications, roads, railways, port, telephone, police, wireless, power and water supply. Considerable damage was caused to irrigation works and local roads in the Madras city before it could recover from the October deluge. 4.4 lakhs thatched sheds were blown off in the districts and about 60,000 houses—tiled and concrete—suffered severe damage. The Amaravathi Railway bridge at Karur was washed away. Besides, a number of breaches in the banks of the Kaveri and the Coleroon caused heavy damages. The Kadaganar dam near Vedasanthur in Madurai district also breached. The damage to public and private properties was estimated at Rs. 155 crores.

On 14th November, 1978, a deep depression crossed the coast near Cuddalore and caused severe rain storms in Ootacamund and concentrated precipitation in the coastal districts of Kanyakumari and Thanjavur resulting in heavy damages to roads, irrigation tanks, channels and railway lines. There were land slides of an unprecedented magnitude and flash floods in the Ootacamund area resulting in loss of a large number of human lives, cattle, damage to houses, roads and agricultural lands. 122 persons lost their lives and 1,418 cattle perished. The value of damage to public and private property was estimated at Rs. 24.89 crores.

Again on 24th November, 1978, a severe cyclonic storm with a gale velocity of 100 to 140 km, accompanied by a tidal wave of 5 to 6 meters height lashed the Rameswaram coast. This cyclone affected to a lesser degree places all along the coast of Thanjavur, Pudhukkottai, Ramanathapuram and Thirunelveli district inundating several Low lying areas. 15 persons lost their lives, 10,200 huts were damaged and the value of damage to public and private property was estimated at Rs. 14.42 crores. It was also an unfortunate onslaught on the same areas of Niligiris and southern coastal districts which had not yet recovered from the effects of the first cyclone.

22.4.5. *West Bengal*

In West Bengal also, the severe cyclones are usually experienced in October and November. The cyclone of October 1942 with a wind speed of 161 km per hour caused a storm surge of 3.5 metres above the normal tide level and caused serious devastation in 24-Parganas and Midnapore districts. Thousands of lives are reported to have been lost apart from tremendous loss of property. In recent years, the cyclone of September 1976 recorded a wind speed of 160 km and caused widespread devastation in the same districts viz., 24-Parganas and Midnapore.

22.5.1. *Measures for mitigating Damage and Distress*

In the wake of the severe cyclone which affected the Andhra coast in 1969 the Government of India, in the erstwhile Ministry of Irrigation & Power appointed a Cyclone Distress Mitigation Committee in December 1969 to examine various measures to mitigate human suffering and reduce the loss of life and property in the event of recurrence of such cyclones in future. The Committee was headed by Dr. P. Koteswaram, the then Director General of Observatories. This Committee submitted its Report in 1971 containing as many as 49 recommendations. Most of these recommendations refer to establishment and observation of meteorological stations with a view to forecast the cyclone and its movement. Dissemination of meteorological warnings has also been dealt with in great details. With a view to reduce cyclone distress, the Committee recommended construction of cyclone shelters, dredging of the mouths of big drains, construction of raised platforms for stacking harvested crops, improvement of road communication between various villages prone to cyclones, setting up of Cyclone Relief Committees etc. Another important recommendation was the need for model studies for the rivers Krishna and Godavari with a view to devise techniques for forecasting the extent of inundation due to rainfall, wind action and storm surge of a cyclone taking into account the existing floods in the rivers. The Committee also recommended that the Central Government should render prompt and timely financial assistance to the State Government for implementation of the various emergency and long term measures recommended by the Committee.

In the wake of the severe cyclonic storm that hit the Orissa coast on the 29th and the 30th October, 1971, the Government of Orissa in the Irrigation and Power Department set up a technical expert committee on cyclones with Dr. A. N. Khosla, the then Governor of Orissa as Chairman. Dr. Ferguson, an expert from Netherlands also assisted the Committee. This Committee submitted its Report in 1974 and recommended the provision of dykes and afforestation in a belt of about 1 km on the sea side where sand dunes do not exist or are not wide enough, afforestation in a width of 1 km along the coast where high and wide sand dunes exist and simplification of the system of rivers and creeks in the coastal belt by reducing the number of outlets to the sea, keeping open the river and other outlets required for efficient drainage of the area, provision of sluices for prevention of tidal bores from entering inland and new drainage cuts in the areas where there is drainage congestion. It also recommended that high mounds should be constructed adjoining low lying villages and road embankments in the coastal area should be provided with wider crests to provide shelter to the people during cyclonic storms.

A Cyclone Distress Mitigation Committee was also set up by the State of West Bengal in 1974.

Recently, after the unprecedented damage caused by the cyclone of the 19th November, 1977, Dr. K. L. Rao, former Union Minister for Irrigation & Power studied the problem and submitted a Report containing recommendations for mitigation of distress caused by cyclones. The recommendations took into consideration the earlier Report and the latest experience of the cyclone of November, 1977. The more important of the recommendations are:

(1) Development of casuarina and other suitable plantation up to a 3 km wide belt along the sea coast to check the velocity of winds and consequently reduce the adverse effects of tides.

(2) Establishment of a research laboratory at Andhra University, Waltair, to supply timely information and general literature to the coastal people regarding cyclones so that steps can be taken promptly to reduce the distress.

(3) To establish and expand an 'S' band radar station at Machilipattinam for tracking cyclones more accurately than with the present radar stations at Vizag and Madras.

(4) Special shelter buildings to be built each for accommodating over 500 people which can be used for community and school purposes in normal time.

(5) Solving the drainage problem in Guntur district.

(6) Setting up self-recording rain gauges and anemometers at selected places along

the Andhra coast for measurement of rainfall and velocity of winds and communication of this data to the people.

(7) Setting up of two special organisations, one based at Machilipattinam and the other at Vishakapatnam for taking systematic action against cyclone havoc.

22.5.2. *Implementation*

The I.M.D. which is mainly concerned with cyclone warning, has implemented a number of recommendations made by these Committees. Cyclone warning radars with a range of 400 km which is approximatey 24 hours journey time for a cyclone, have been set up in Calcutta, Paradeep, Vishakapatnam, Madras, Bombay and Goa. In the East coast, the network is proposed to be extended by the setting up of a radar each in Masultipatnam and Karmaikal in 1980 and 1981. Cyclone Warning Centres are required to cater to the needs of coastal belts prone to cyclones. Since the State Meteorological Centre for Andhra Pradesh is far away at Hyderabad, a separate cyclone warning centre has been established at Visakhapatnam to meet the requirements of the coastal areas. The State Meteorological Centre at Bhubaneswar is looking after the cyclone warning service also for that reach. Sixteen special observation stations have been established along the Orissa coast and 14 along the coast of Andhra Pradesh. A few stations are likely to be established shortly along West Bengal and Tamil Nadu coasts. These observatories record only rainfall and wind observations and transmit them through high-priority telegrams to the concerned Cyclone Warning Centres during periods of cyclones. Self-recording instruments have been installed in all the departmental observatories along Orissa and Andhra coasts. Special arrangements have also been made to send an alert message to the collectors of the concerned districts and the Chief Secretary of the State at least 48 hours before the expected time of arrival of a cyclone. This is the first-stage warning. It is followed by a second-stage warning at least 24 hours before the cyclone strikes the coast. Subsequently the district collectors are kept informed about the cyclone at frequent intervals until the danger to the districts is over. AIR stations broadcast frequent warnings mostly at hourly intervals and upon receipt of communication about sudden unexpected developments. The recommendations for provision of instrumented aircraft for cyclone reconnaissance is under consideration of the Government of India.

In the wake of a cyclone, the State Governments promptly carry out the usual relief measures and make the required arrangements immediately for rehabilitation etc. However, th long term measures are not taken up with expedition as the State Governments look up to th Central Government for financial help.

Depending upon the funds available with then the State of Andhra Pradesh is implementing th various measures recommended by various Committees. Accordingly, some cyclone shelter have been constructed. Work is in progress i respect of drainage of the Upputeru. Improvements in other drains in the Krishna and Godavari delta areas are being carried out under th Krishna Godavari delta drainage scheme. Th model studies recommended to be taken up i collaboration with the CWPRS, Pune, for th rivers Krishna and Godavari are, however, ye to be taken up.

As regards the recommendations of Dr. K. I Rao, the State Government promptly took u urgent relief measures. It restored the damage public works and took ameliorative measures fo restoring agricultural production and credit supply to farmers. Other measures, however, ar under consideration.

In Orissa, the State Government has take action in respect of renovating drainage channel and removeal of water logging. Existing mound have been located and improvements to them ar being carried out with finance from the Government of India. Some of the other recommendations are expected to be implemented after th receipt of contour plans which work has bee entrusted to the Survey of India.

The recommendations of the Cyclone Distres Mitigation Committee set up by the State of Wes Bengal are under consideration/implementation

22.6.1. *Mitigating losses*

The occurrence of cyclones cannot be prevented. They are a natural phenomenon like a earthquake or the eruption of a volcano. These calamities have to be viewed in the context o preventive measures to be taken and developing a sense of preparedness amongst those likely t be affected.

The important steps that could go a long way in reducing the loss—both to lives as well a property—resulting from cyclones, are detailed below.*

22.6.2. *Forecasting and Warning*

The alerting of the community must begin by the concerned authorities as soon as the existence of a tropical cyclone over the sea bordering the ountry is known. The earliest information that he Meteorologist can give regarding the formaion and possible movement of a tropical cyclone owards the coast helps other components of the mergency organisation to reach a state of full eadiness in good time for making all the prepaations that have to be made. For ensuring this, ve should install additional observation facilities o supplement the basic meteorological network equired for normal forecasting and climatologial needs of aviation, industry, agriculture, hipping, etc. The additional facilities required vould be weather radars, auxiliary reporting tations, inflight reports from aircrafts, aircraft econnaissance reports, telecommunications, etc.

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*Ref. "Guidelines for Dirsaster Prevention and preparedness in Tropical Cyclonic Areas", prepared by the ESCAP, WMO and League of Red Cross Societies.

The IMD which is already carrying out most f the above work has prepared a project in this egard and has identified 14 recommendations vhich are enclosed as Annexure 22.1. We endorse ll these recommendations subject to the availbility of finance.

2.6.3. *Administrative and Legal measures*

The consequences of calamities caused by a yclone are so serious that much greater emphais should be given to national planning and relucing damages. This becomes very important n account of the rapid urbanisation and high ates of population growth in vulnerable areas. Though it is not possible to forecast much in dvance, as to when and where a cyclone may it, it is possible to make an assessment of the vulnerability of different countries or regions. Therefore, human activities should be limited in areas which are exposed to cyclones.

Disaster prevention policies should encourage the incorporation of disaster prevention as one of the variables in the normal process of social, economic and physical planning. Disaster prevised to keep their receivers switched on and ration of micro zoning maps for such hazards, (b) land use and zoning laws to restrict or prevent industrial and/or residential development in areas where risk is high, (c) building codes setting out minimum safety standard in cyclone vulnerable areas, (d) soil and plant conservation measures to guard against erosion, (e) engineering measures relating to protection of areas vulnerable to flooding or storm surge, and (f) public health measures concerned with sanitation.

The implementation of measures designed to prevent or mitigate the damages likely to be caused by tropical cyclones should take into account risk evaluation or, in other words, an assessment of the vulnerability of the area to disaster. The probability of storms of various intensities striking the country should be studied and specified intensities should be used for designs in different parts vulnerable to cyclones. This will enable the Engineer to fix up the design criteria for different sizes of buildings or different heights of embankments to be erected at various elevations above sea level.

Land use and zoning are very essential because protective engineering works alone cannot guarantee banishment of catastrophic flooding for all time. These works can at best present a barrier to the advance of storm driven seas. Therefore, they can only mitigate flood hazards and the resulting losses, but there are always limitations to the effectiveness of these devices. Moreover, such protective structures may gradually become insufficient when new development is allowed to encroach into damage prone areas. It is, therefore, essential that the general range of land use control including building codes recommended for flood prone areas may also be applied for these areas. This subject has been dealt with in some details in Chapters V and XI.

Casurina and other plantations should be taken up for a width of about 2 km along the sea coast wherever feasible to break the wind velocity and thus reduce the height of tides.

In the coastal areas, special shelter buildings especially designed for cyclone conditions should be constructed at suitable intervals to cater to the need of people living in low-lying areas. These buildings should be multi-purpose and can be used as schools or community centres during normal periods.

Future coastal embankment projects in deltaic areas should be planned in conjunction with other development projects such as highways, harbour and reclamation projects in order to avoid duplication of investment costs.

22.6.4. *Preparedness*

Disaster preparedness is seen in action in the short-term or emergency measures which come into force when tropical cyclones approach and bring with them the threat of a disaster. These measures remain in force until sometime after the disaster has passed.

It is necessary that a National Council for Mitigating Disaster is formed which would involve almost every sector of the community—the Ministries/Departments responsible for defence, transport, highways, public health, social welfare, agriculture and forestry, communications, housing, education, meteorology and hydrology. Finance, also should be represented. Besides, non-Governmental bodies such as the National Red Cross and also be included in the Board. The effective cooperation of the public is also needed and there should be full scope for them to play their role in the deliberations of this Board. There should be a corresponding Board/Committee at the State and District levels. In each district, there should be a local Disaster Mitigating

Committee which should include representatives of local authorities, civil defence, police, public works, public health, medical services, fire service, utilities like transport, electricity, water and P&T, education and national Red Cross. The Committee should meet as often as necessary till a satisfactory plan of disaster preparedness has been drawn up. Thereafter, the Committee should meet regularly and should invariably hold a meeting as the cyclone season approaches. The Committee should make necessary visits and ensure that all necessary arrangements have been made for coordination, collaboration and teamwork.

Effective dissemination is a vital part of the warning system. If the organisation for disaster preparedness functions speedily and efficiently, emergency forecasts and warnings will reach all residents, officials and the general public with the least possible delay. For forecasts and warnings to officials and agencies which have decisions to make and work to do on the approach of an actual emergency, the main requirement is an adequate network of operational communication facilities connecting the warning service to all who must receive warnings and to one another for consultation and coordination. The preparedness of the public during the approach and actual state of emergency is best guaranteed by ensuring that full information and advice about the threatening dangers are readily available to all. For this purpose, the mass media—radio, television and the press should be utilised. This is being done to a considerable extent in the coastal States. When the first issue of a tropical warning is made by the IMD, the population should be advised to keep their receivers switched on and tuned to a specified frequency so that all relevant forecasts, warnings and other instructions may be received.

Flood fighting and evacuation of danger areas should be undertaken as detailed in Chapter V.

22.6.5 *Public Information & Education*

People who have experienced cyclones are usually ready to pay particular attention to any warnings that are issued and to follow the advice that is given, including any instructions for evacuation to safe areas. It is necessary to ensure that all people, not only those with actual experience, have an awareness of the dangers posed by cyclones. Indeed, since memories are apt to fade, the awareness must be kept alive and up to date among those whose experience of a cyclone is not very recent. Public information and education must, therefore, be an essential component of disaster preparedness. If the general public is kept fully and constantly informed of the disasters which cyclones can bring, the organisation and operation of disaster preparedness system would have every chance of functioning smoothly and efficiently. In this context, education is the natural complement to the provision of information. And education programmes designed at proper levels for children and adults should impart basic knowledge about the nature of cyclones and the risks involved and about warning services and protective measures. Education programmes should be supplemented by campaigns through the press, radio and television. These campaigns should be made more intensive as the cyclone season approaches and posters and pamphlets in local languages should be displayed and distributed.

Planning and organisation of disaster preparedness should be kept under constant review. This practice can be undertaken by regular meetings at different levels of responsible officials of the various agencies involved in disaster preparedness and also by holding exercises in order to test the readiness and efficiency of the organisation as a whole or of selected portions of it.

22.6.6. *Emergency Operations and Disaster Relief Action.*

Each disaster brings the following results:—

(1) People are affected through death, injury, illness or grief and shock.

(2) Communities are affected due to destruction of or severe damage to structures and utilities such as schools, hospitals, factories, roads, bridges, railways, harbours and airports etc. causing severe dislocation of services and communications.

(3) Disruption in systems and services such as health and welfare services, functioning of schools and religious centres, is caused.

During the emergency, the different kinds of action that will have to be taken will include the following:—

> Warning; rescue, evacuation; flood fighting; public safety; relief to families and individuals; disaster survey and assessment; communication, transportation, supply and storage; public information; social welfare services and external aid and its co-ordination.

22.6.7. *Rehabilitation.*

The basic purpose of rehabilitation is to provide services and facilities which will restore to communities, families and individuals their normal living standards while at the same time encouraging adjustments to drastic changes caused by the disaster that has occurred. If as a result of the damage suffered in the locality, a large scale programme of rehabilitation is required, the main aim should be to improve rather than to merely restore the accustomed living standards and social conditions. Rehabilitation should be carried out under two programmes covering the victims of disaster on the one hand and public services and amenities on the other. Assistance of the victims may include the repair of homes, provision of basic home needs such as furniture and kitchen utensils, provision of clothing and resettlement etc. Resettlement may also include relocation in the area or in the region of origin, which should be very carefully done so that temporary settlements would become permanent only if they are suitable.

22.6.7. *Funding*

The State Governments will not be able to meet the entire cost of measures required to be taken for the prevention, preparedness and relief in respect of cyclonic disasters. Therefore, the installation, operation and maintenance of all equipment for forecasting and dissemination of warnings should be carried out as a part of the central programme, by the Central Government Departments like IMD, the Railways and P & T. The financing of engineering works like coastal embankments and permanent shelters as protection measures should be as per recommendations for flood control schemes made in Chapter **XVI.**

सत्यमेव जयते

22.7. Introduction

The erosion and growth of breaches is not a new phenomenon that has assumed alarming proportions recently. Historical as well as other records bear testimony to the almost unavoidable transformations that coast lines have undergone in the past due to ravages of the sea. These changes were generally due to natural causes like a gradual climatic change causing variations in wave energy or direction of wave attack, reduction in the discharge of sediments from rivers, tectonic upheavals, rise in sea levels, etc. Whatever may be the cause, a sea coast is eroded when the material being removed by the sea for deposition elsewhere exceeds the rate of supply. It is a matter for concern that today, some of the adverse effects along the coast are not due to natural causes but attributable to human interference in the normal course of the forces at work along the shores.

22.8 Problem

The Indian sub-continent has a total coastal length of about 5,700 km distributed among the coastal States as indicated below:—

1.	Andhra Pradesh	960
2.	Gujarat	1600
3.	Karnataka	280
4.	Kerala	560
5.	Maharashtra	512
6.	Orissa	432
7.	Tamilnadu	980
8.	West Bangal	280
9.	Goa & Pondicherry	104
	TOTAL	5708

The problem of coastal erosion is not experienced along the entire coastal length of the country but only in patches, except in Kerala, where the problem is somewhat extensive and serious. The problem also exists at a number of isolated places along the Indian coast viz. near ports, harbours, river mounths, sea resorts and promontories.

The problem as experienced in the different States is described in the following paragraphs.

22.9 Kerala

Kerala State is a narrow strip of land bordering the Arabian sea. The width of the State from the coast to its eastern boundary in the Western Ghats varies but does not exceed 160 km. The distance from the westerly slopes of the Ghats to the sea shore also varies, but averages about 54 km. Of the 44 rivers draining the State, 41 flow westerly from the mountains to the low area back waters and lagoons near and at the coast. In the coastal region, the rivers are generally interconnected and tidal.

Out of the 560 km of the coast line, approximately 320 km are subject to erosion, the problem being quite serious in many sectors. The coastal strip of land along the Arabian Sea is heavily populated. Erosion of the shore by waves and tide-induced currents results in damage to and/or loss of, buildings and agricultural land and crops. Frequent flooding of the sea over this strip of land into the back waters and low lying areas during the south-west monsoon season, causes a lot of damage.

22. 9.1 *Coastal changes*

The shore off the coast of Kerala is of recent geological origin and is made up of recent sediments which are still in an unconsolidated state and have yet to reach equilibrium. Historically, the Kerala coast line is reported to have retrograded considerably during the last century or more. The net progressive loss of land is estimated to be 2 to 5.5 meters per year. There are also seasonal changes in the shore line of the coast during the year. From April to September, there is continuous erosion which is made up by deposition during the non-monsoon period. This berm crest that fluctuates during this seasonal change, is estimated to be more than 50 metres in one season. The Kerala coast is also known for the peculiar phenomenon of mud banks. These mud banks are formed off-shore—one south of Alleppey, one north of Cochin and two near Kozhikode. These mud banks have the special property of dampening wave action and producing regions of calm water even during the rough monsoon season due to the dissipation of wave energy in the large quantity of colloidal suspension in the region. The mud bank region is considered a boon by the local people as these areas which are calm during the monsoon abound in prawns, sardines, mackrels and soles. The coast line being very low, back shore areas are flooded by the storm tides in many reaches when the south-west monsoon strikes the coast.

22.9.2 *Littoral drift along the kerala coast*

Littoral drift along a sea coast is the quantity of beach material that moves parallel to the coast in the near-shore region of the sea, essentially caused by the waves approaching the beach at an angle. In the Kerala coast, the predominant direction of littoral drift is towards the south. But the direction of the drift changes according to the season, the movement being south during April to September and north during the rest of the year. The quantum of gross littoral drift has been estimated to be about 1.25 million cu. meters per year.

22.9.3 *Causes of beach erosion*

Lack of littoral supply due to the influence of mud banks, the presence of littoral barriers like the Cochin channel and non-replenishment of sediment from upland sources are the major causes of erosion. Many rivers drain into the back-waters, consequently the sea is deprived of the river sediment which would otherwise have found its way to the sea for feeding the littoral currents. There are number of river mouths which have a migratory tendency and the down drift side of such outlets is subject to erosion. Laterite cliff erosion is noticed north of Tellicherry and south of Quilon. This is due to the continuous pounding of waves which undermine the base of the cliff resulting in slide failures. Recently, the construction of breakwaters at major and minor ports and other minor structures have also caused disturbance in the natural process of beach formation resulting in erosion on the down drift side.

22.9.4. *Measures taken up so far*

Measures for arresting coastal erosion were taken up on a minor scale in the Cochin area, as early as 1890. However, it was only after 1953, when serious erosion caused heavy damages that definite steps were launched against sea erosion.

During the course of the last 25 years, various types of coastal works have been tried to evolve a suitable and satisfactory design which will withstand the attack of the severe waves and storms and thereby check erosion effectively. The earlier pioneering structures, mainly by way of sea-walls and groynes, with different combination of construction materials, were necessarily, experimental. Since then, based on analysis of fresh data and model studies, an economical design of sea wall with a seaward slope of 1 in 5, lower crest elevation and lesser size of armour stone to suit the Kerala coast, has been evolved and its effectiveness is being tried at selected locations.

To prevent coastal erosion due to reduction in littoral supply, the logical solution would be artificial nourishment of the beach effected with natural sand supply to the littoral current. This was experimentally tried at Purakkad with limited success. However, this remedy has not been possible of application elsewhere due to non availability of sand as also the equipment required for transporting and injecting the sand in the littoral current.

22.9.5 *Financial and physical achievements*

The programme of anti-sea-erosion works undertaken by the State up to 5th Plan is as under:—

Plan period	Plan expenditure (Rs. in lakhs)	Comulative physical achievement (km)
I Plan	Nil	Nil
II Plan	184.020	N.A.
III Plan	439.980	N.A.
Annual Plans 1966–69	161.448	78.680
IV Plan	1013.476	113.935
V Plan	997.140	188.871
TOTAL .	2795.064	

22.9.6 *Work to be done*

At the end of the 5th Plan, 189 km had been protected and 131 km remained to be treated. Based on latest estimated costs of Rs. 25 to Rs.30 lakhs per km the State has estimated the requirements for protecting its vulnerable coastline as Rs. 45 crores during the VI Plan.

22.10 **Tamil Nadu**

Tamilnadu has a shore line of 982 km of which 920 km lies on the east coast and 62 km on the west coast. There has been erosion in isolated places and serious damages had been reported from time to time. The coast being vulnerable to cyclones, storm surges also affect the coastal areas causing inundation of low lying areas with the resultant damages to crops and property. Fishermen who depend on near-shore fishing with the help of country craft invariably reside very close the sea coast and it often happens that their hutments are the areas badly damaged when there is sea erosion or a severe storm tide.

22.10.1 *Location of the erosion problem*

Overi, Manappadu, Thiruchendur, Dhanushkodi, Mahabalipuram, and Royapuram north of Madras harbour are locations where the problem may be considered as of special importance. The erosion problem is also reported to exist in Erandurai, Enayam, Meedazham, Puthur, Kolachal, Mattan, Rajakamangalamthurai, Kesavan Puthanthurai, Kanyakumari along the west coast and Idinthakarai, Rameshwaram, Nagappattinam, Kaveripattinam, Kovalam and Ennore along the east coast.

22.10.2 *Measures taken so far*

In 1964, Mr. Watts, inspected some of the places. Since available data was insufficient to permit a good engineering analysis of the problem, he could not develop alternative economic plans of improvement as against the emergency protection arrangements that were being adopted. He made some suggestions regarding the protection to be carried out and advised long term data collection programme. This data collection was carried out from 1969 to 1973 by the Institute of Hydraulics and Hydrology in Poondi and a detailed repodt prepared in 1976.

The temporary protective arrangements of driving rows of casuarine piles filled with granite stones of 1 c.ft (0.03 m^3) provided in certain places along the Arabian sea coast in Kanyakumari district did not prove successful and it was decided to construct rubble mound type of sea wall along this reach. A Project Report for the purpose which was prepared earlier has since been revised to cost Rs. 590 lakhs for protecting 30 km of the coast and is with the State Government for transmission to the centre. In the meantime, since serious erosion at Enayam and Muttanthuzhi in Kanyakumari district was experienced in 1976, the Government of Tamilnadu has sanctioned Rs. 46.40 lakhs for construction of 1.6 km length of rubble mound sea wall at Enayam, Rs. 14.50 lakhs for 0.5 km at Muttanthuzhi and Rs. 5 lakhs for 0.22 km of sea wall at Ponnivokkal. These works have been taken up. Similarly on the east coast, there has been serious erosion in Poompuhar in Thanjavur district and at Kovalam, 64 km south of Madras, which became acute after the cyclones of 1977. Action for taking up remedial works is being initiated by the State Government.

Apart from the erosion caused by natural causes as stated above, there has been continuous erosion on account of the construction of the Madras Harbour, in the down drift side, that is, north of the harbour at Royapuram. The Institute of Hydraulics and Hydrology, Poondi, is conducting detailed field investigations and model studies for finding suitable remedial measures against sea erosion in this area. Pending finalisation of the studies, the State is considering taking up temporary protective arrangements both at Royapuram and Ennore in the north and at San Thome in the south.

22.11 Andhra Pradesh

The maritime State of Andhra Pradesh has a coast-line 960 km long facing the Bay of Bengal. The State has 8 sea ports of which Vishakapatnam is the major port and Kakinada and Machilipattinam are two intermediate ports. The remaining 5 minor ports are Kalingapattinam, Bheemani-pattinam, Naraapur, Valareva and Krishnapattinam.

22.11.1. *Littoral drift along the Coromandal coast*

It has been established that the movement of littoral drift along the Coromandal coast is predominantly from south to north. Geologically, the east coast of India is an eroding coast whereas in actual practice, the amount of nourishment provided by the littoral drift helps to maintain the coast line in a state of equilibrium. Therefore, wherever any obstructions like groynes, sand traps, inlet channels etc., are encountered by the drifting sand at the sea coast, due to construction of either groyens, sand traps, inlet channels etc., the coastal reach north of the obstruction gets eroded on account of starvation of the nourishment due to the break in the littoral transport of sand. The intensity of erosion will depend on the amount of sand nourishment deprived.

22.11.2. *Location of the problem*

In Andhra Pradesh, only two places in the vicinity of ports experience serious erosion. One is the beach area of the Vishakapatnam town and the other the coast near Upada.

22.11.3. *Vishakapatnam*

The history of erosion at Vishakapatnam can be traced to as far back as some time in the 19th century when, on the recommendation of Sir Arthur Cotton, 5 groynes were constructed to the north of the present port. There is evidence to suggest that there was erosion even before the construction of the Vishakapatnam port in 1935. Perhaps, the erosion before the construction of the port might have been due to the incomplete transfer of littoral drift across the then existing inlet at this place. To prevent the erosion, sea walls and groynes were constructed, but these were badly damaged and had to be maintained at considerable cost.

During his visit in 1964, Mr. Watts, an American expert, felt that the erosion was due to insufficient passage of sand to north of the entrance channel of the port. He advised that the coast line north of the port should be nourished by pumping the requisite quantity of sand so as to restore equilibrium. Accordingly, model studies were conducted at Khadakvasla Research Station, Pune, as well as at the National Research Council, Ottawa, Canada and it has been established that annual amount of 4.4 lakh cu m of sand is required to nourish the coastline north of the Vishakapatnam port and maintaining equilibrium. The outer harbour project costing Rs. 200 lakhs is under execution and it provides for pumping the required quantity of sand for nourishing the coastline north of the entrance channel. It is hoped that, with the implementation of this project, the erosion in the vicinity of Vishakapatnam port will be eliminated.

The Beach Erosion Board has recommended the progressive construction of a sea wall in the reach between the Coastal Battery and the Palm Beach Hotel with a view to provide a second line of defence. But due to paucity of funds, this suggestion has not been implemented so far. The CWPRS has advised that there is no need to conduct any more model studies if 4.25 lakh cu m of sand is pumped annually to nourish the starved coastline north of the port. Still the Beach Erosion Board has suggested a comprehensive scheme of field investigation for watching the behaviour of the coast from Beemunipatnam located at a distance of 32 km north of the Vishakapatnam port, to Balacheruvu situated 12 km to the south. This suggestion also has not yet been implemented due to lack of funds. The Vishakapatnam port authorities are, however, carrying out beach surveys on a continuous basis in the reach from the port to Lawson's bay.

22.11.4. *Erosion at Upada*

Upada is a village located 11 km north of Kakinada port and has been subject to coastal erosion for a long time. The rate of erosion has been estimated to be of the order of 30 m during a period of 3 years. Erosion has also been noticed further north up to a distance of 10 km from Upada, the principal damage being to hutments and to Kakinada and Palmora plantations.

The erosion at Upada is due to the peculiar feature of the coast in this area. There is a long narrow sand spit 16 km in length called the Godavari sand spit. This is known as Hope Island and it has been steadily maintaining its length due to progressive deposition of sand transported by waves in the form of littoral drift travelling up from the south. The Godavari sand spit forms a big bay called the Kakinada bay measuring about 100 sq. km. This bay which is open from the north breaks the continuity of the shore line and consequently the movement of littoral drift along the coast result in deposition at the head of the sand spit. Thus, the littoral supply does not reach Upada which results in the wave energy picking up material from the coast near Upada. The only remedy for this erosion is nourishing the coast with adequate quantum of sand of appropriate grade, size and distribution. The development envisaged for the Kakinada port would require capital as well as maintenance dredging. The Beach Erosion Board which went into the problem has observed that there are practical difficulties in arranging for deposition of the dredged spoil in the affected zones opposite to Upada on account of the long length of the conveying pipeline that would be required and also the difficulty of obtaining a suitable dredger on a continuous basis from the available dredgers in the country. The Board has, therefore, suggested to the State Government to conduct detailed investigations in the area adjoining Upada and examine if nourishment of sand could be achieved either by stockpiling of material borrowed from nearby areas or devising means to pump sand from the near shore area opposite the coast of Upada. The construction of a sea wall in the most vulnerable reach has also been suggested subject to justification of the cost and value of property protected.

In order to take up the investigation of the coast line at Vishakapatnam and Upada, as advised by the Beach Erosion Board, the Directorate of State Ports, Kakinada who has the necessary equipment and technical knowhow, has submitted an estimate amounting to Rs. 17 lakhs. However, the State could not provide the requisite funds for this work from its resources and the Chairman of the Beach Erosion Board was addressed to arrange for Central assistance. According to information from the State, no positive response has been received so far.

In the draft Master Plan prepared for flood control/protection schemes by the State Government, an amount of Rs. 100 lakhs has been provided for anti sea erosion works.

22.12. Orissa

The coast line of Orissa is 432 km long. The special feature of this coast line is the major sediment contribution from the river systems to the creation of deltas into the Bay of Bengal nearly all along the shore line of the State. Sediment contribution to the coast by the river systems has exceeded the capacity of the littoral forces to move these sediments. Hence there has been progressive growth of the deltas into the Bay of Bengal, and Orissa has been considered a 'growing State'. Massive sand dune systems exist along many kilometers of the coast, indicating that the river sediments also contain considerable quantities of sand.

The erosion problem is reported to be due to the reduction in the littoral drift that moves along the coast due to:

(i) Retention of sediment in storage reservoirs constructed on the rivers that bring nourishing material.

(ii) Reduction in the movement of the drift material due to construction of harbour works specially at Paradeep and Gopalpur.

It is stated that the land at Konarak has extended into the sea by about 10 ft. (3.05 m) per year over the past 700 years. If this were due to the sediments that the rivers brought to the sea, it may be conjectured that reduction in silt loads due to reservoirs and soil conservation etc., may result in land recession at about 10 ft. (3.05 m) per year. However, on account of lack of quantitative data and the fact that the sediment detention reservoirs are and will be located sufficiently inland, it has not been possible to predict the interval of time that it may take for the shore zone adjacent to the river mouths being influenced, if at all.

The coast line near Paradeep is reported to be eroding very fast. This problem has been under constant review by the State Government and the Central Water Power Research Station, Pune. The CWPRS has conducted extensive model studies to determine the optimum nourishment required for keeping the northern coast line in equilibrium. It has been estimated that about 0.6 million cubic meters of nourishment would be required for this purpose annually. However, the port authorities are unable to fully supply the required nourishment even after trucking of sand from the southern fillet. In order to keep the entrance channel to its proper width and depth with the available dredger working for this purpose, the reclaimed material was dumped in the deep sea instead of placing it on the northern side for nourishing the beach. It is necessary that arrangements are made for transfer of the full quantum of littoral drift as nourishment for the northern shore so that further erosion can be arrested.

A similar problem is also reported at Gopalpur port. The CWPRS has recommended a layout consisting of an island break water with a sand trap at its lee from where material could be dredged and by-passed to the northern side. Alternatively, another proposal consisting of a channel protected by a breakwater on the southern side and a sand pump working over a trestle on the northern-side for dredging and by passing sand from the channel has been recommended. These recommendations make it clear that down drift coast needs to be nourished by transfer of the material arrested.

Linked with the problem of Gopalpur port, is the famous religious town of Puri, also situated on the east coast in the State. At present, perfect equilibrium is being maintained along the coast near Puri by the natural forces of littoral drift. In case, however, there is reduction of littoral material due to construction of harbour works without arrangements to transfer the arrested material at Gopalpur, the coast near Puri town is likely to be adversely affected.

In addition to the problem at Paradeep and Gopalpur as mentioned above, it has been reported by the State that a recent survey has brought to notice serious erosion problem in the small Hookitola area projecting into the Bay of Bengal. This area is about 11 km north of the outfall of the Kendrapara canal and within a distance of 15 km from Paradeep port. The actual survey conducted in 1979 when compared to the air survey map of 1929 goes to show that there has been an erosion to the extent of 5800 ft. (1768 m). The erosion at present is proceeding in such a way that this area which is like a peninsula jutting into the sea, may get detached from the mainland and an island formed in the first stage. The report states that in course of time this island may also disappear due to erosion, if remedial measures are not taken in time.

Apart from sea erosion, a major problem reported along the coast is wind erosion of the sand dunes, which renders agricultural land unproductive, and reduces the protective potential of the sand dunes against tidal floods during cyclones. It is planned to counter this by raising of Shelter belts-cum-wind break plantations on scientific lines along the coast so as to reduce the drifting of sand caused by heavy winds as well as minimise the unwanted effects of cyclones. The proposed plantations are of Casuarina and Cashewnut trees. A special technique of planting known as 'brick planting' is adopted. By adopting this method, 20 rows of Casuarina are proposed to be planted along the sea coast as a first line of defence. The area thus protected is divided into compartments of 10 acres (4 ha) each by raising internal wind breakers all along the plantation. This arrangement prevents wind erosion and sand drifting. These compartments can be then planted with Cashewnuts adopting 25 ft (7.6 m) spacing. Cocoanut plantation can be taken in between cashewnut rows on a plantation scale. Every cocoanut plant will be protected from sand casting, brackish wind and strong sun light by a vegetative screen. Further, sea water agriculture is proposed to be adopted with a view to grow salt-tolerant crops and plants on the sand dunes, taking advantage of the seasonal rainfall and the salinity of the sea water as a supplementary source of irrigation. If such a programme of plantation and sea water agriculture is implemented successfully. it will provide employment opportunity to the coastal fishermen and add to the foodgrain production of the State. The sand dunes will also be established, and the coast protected from tidal floods.

22.13. West Bengal

The Bay of Bengal forms the southern boundary of West Bengal. The sea coast stretches from Digha in Midnapore district at the western end to the outfall of the Raimongal river in the 24 Parganas district at the eastern end. The coast line extending from Digha in the west to the confluence of the river Jagaddal in the east experiences erosion.

Local investigations are reported to indicate that during the last 25 years, the sea has advanced inland by about 1.6 km in the Fredrick Island area. The temple of Kapil Muni at Gangasagar, situated within the Sagar island had to be shifted inland by about 5 km within the last 10 years. The local inhabitants in this reach of the coast were forced to move further inland when valuable land and properties got engulfed by the sea. In Digha area of Midnapore, the rate of erosion is reported to be very severe. A study of the beach cross section near the Digha coast indicates an annual rate of erosion of the order of 10.66 metres.

Erosion generally takes place as a result of storms and cyclones which tend to create increased wave heights and wave energy. The problem of sea erosion is also reported to be aggravated by the fact that the littoral drift from the adjoining coast in Orissa by passes the coastal area of West Bengal and gets deposited in the deep sea. The natural defence against sea erosion is an adequate beach where the waves lose their energy and do not get direct access to the land behind the beach. However, provision of an adequate beach is not always economically feasible. Under such circumstances, sea walls have been employed. Of the various types of sea walls, rubble mound sea wall is adopted on account of the availability of the required stones and the facility of construction.

22.14. Karnataka

The 300 km coast line of the State lies on the west coast of India between Mangalore in the south and Karwar in the north of the State. In this stretch, many major rivers such as the Kali, the Sharavathy, the Kollur, the Gurpur and the Nethravathi enter the Arabian Sea. The completion of the Kali bridge will provide uninterrupted road communication from Bombay to Kanyakumari. The hinterland being rich, a number of big and small industries have been set up along the national highway. This in turn has increased the necessity of protection of the coast line from the ravages of the sea.

22.14.1. *Coastal problem*

It is reported that the coastline has been suffering serious erosion over the past many years. The river mouths are exhibiting a dangerous tendency to migrate whereas within the tidal reach of these rivers, bank erosion is an added problem. These phenomena are not only hindering the economic activity of the people, but have resulted in loss of valuable land, property cocoanut plantations and built-up structures. The areas affected by the erosion have been grouped under three categories *viz.* (1) the open beaches, (2) the river mouths and (3) the river banks in the tidal reaches.

22.14.2. *Open beaches*

In Dakshina Kannada district, approximately 21 km of coast is affected, the most problematic reaches being at Maravanthe, Mangalore, Sahihitu, Uliargoli, Padikere etc. It is proposed to build rubble mound sea wall estimated to cost Rs. 30 lakhs per km as adopted in Kerala. The approximate cost has been reported as Rs. 6.3 crores. In Uttara Kannada district, about 13 km of coast is exposed to erosion which is estimated to cost about Rs. 3.9 crores. The locations are Bhatkal, Shirali, Manki, Gokarna, Karwar and Devbag.

22.14.3. *Stabilisation of river mouths*

The mouths of the Nethravathi and Gurpur rivers in Dakshina Kannada district are tending to shift northwards eroding the Bengre sandspit thereby affecting dwellings, roads and auction sheds etc. If this trend is allowed to continue the old Mangalore port area may be exposed to waves and it would disturb the working of the very port itself. The approximate cost of providing rubble mound jetties or breakwaters to stabilise the mouths is expected to be Rs. 2 crores.

In Uttara Kannada district the northern sandspit of Mallakurve at the mouth of the river Sharavathy has almost disappeared. The adjoining area of Pavinakurve is now under attack. It is estimated that the stabilisation of the river mouth which has already migrated northwards by about 500 meters by the construction of jetties will cost about Rs. 2 crores. Similar works are required at Shirali for training the Venkatapur river which is expected to cost about Rs. 1 crore.

22.14.4. *Bank protection in the tidal reach of rivers*

The problem of bank erosion due to the rise and fall in the tides as well as the floods during the monsoon has caused considerable damage to valuable plantations along the river edge. The cost of protection and reclamation of such banks along the rivers Seethanadi, Halady and Kollur in Dakshina Kannada district is estimated as Rs. 1.65 crores. Similar protection for the rivers Venkatapur, Sharavathy and Badagiri in Uttara Kannada district is estimated to cost Rs. 0.75 crores.

22.14.5. *Financial requirements*

An abstract of the protection works as estimated by the State is shown below:—

District	Sea walls for open/beaches at Rs. 30 lakhs/km		Jetties (breakwaters) for training rivers at Rs. 1 Crores/ km		Bank protecion in the tidal reach of rivers at Rs. 15 lakhs/ km.	
	Length	Cost	Length	Cost	Length	Cost
Dakshina Kannada	21 km	6.3 crores	2 km	2 crores	11 km	1.65 crores
Uttara Kannada	13 km	3.9 crores	3 km	3 crores	5 km	0.75 crores
Total	34 km	10.2 crores	5 km	5 crores	16 km	2·40 crores

Grand total (Rs. 10.20 + 5.0 + 2.40) = 17.60 crores.
add 25% for escalation of cost odf materials and labour over a 5 year period 4.40 crorcs
Rs. 22.00 crores

Grand total (Rs. 10.20+5.0+2.40) =17.60 crores
Add 25% for escalation of cost of materials and labour over a 5 year period 4.40 crores
Rs. 22.00 crores

22.15. Maharashtra

The problem of coastal erosion in the State is not very severe and is experienced in isolated patches. It is of significance only at Versova and Ratnagiri.

The Versova beach is located immediately to the north of the city of Bombay and could be considered as a suburb of that city. The shore line at Versova is slightly concave in plan. Malad creek which is tidal, is located at the northerly end of the beach and a rocky headland forms the northerly boundary of this creek, with the Arabian sea. South of Malad creek, shore erosion prevails for a distance of about 3500 ft. (1067 m) and there is essentially no dry beach fronting the residential plots during higher tide.

In 1964, Mr. Watts, the American expert suggested the adoption of beach fill and periodic placement of additional sand to maintain the desired beach dimensions. It was also felt by him that as the annual nourishment required would be minimum of 50,000 cubic yards (38228 m^3) and the placed sand would be transported off shore, for the most parts, a system of groynes in conjunction with the fill and nourishment programme would provide negligible benefit. He, therefore, recommended a rubble revetment and/or construction of sea wall along the problem area. At the same time, he recommended that in case suitable sand could be located within a reasonable distance to carry out a beach fill and periodic nourishment plan, the revetment could be eliminated or deferred.

The Versova Beach was inspected by Mr. V. L. Maksinchuk, a UN Expert in May, 1976. He opined that the main reasons of the undermining of the mound rubble stone prism provided for protection was insufficient weight of the armour stones in the prism and absence of filler beneath. As an emergency measure, he recommended building of temporary submerged breakwater from concrete tetropod blocks, each of 1.5 ton (1.52 tonne) weight.

22.16. Gujarat

In contrast to the problem of erosion taking place on a long continuous coastal strip as in Kerala, the problem in the State is more or less of a local nature. There are 7 main coastal areas in the State which need protection against erosion. These are Ghogha, Umbargaon, Baghwa, villages on Konai Greek, Dumas (near Surat), Kolaka and Koteshwar. The sites are far apart and the condition of each site is different. Erosion is taking place mostly under the action of strong tidal currents accompanied by wave action.

In 1957, the State Government had constructed double walls in some lengths and single walls for the balance for protection of the coast near Dumas. The State has a proposal to convert the single wall portion into double wall by adding toe wall and rubble pavement and also to extend the double wall further south.

The Government had prepared a plan costing Rs. 1.20 crores for anti-erosion works in the State. It has also been proposed to set up a coastal erosion cell to study the causes of the problem. This cell would also collect relevant data and suggest protective measures in consultation with the CWPRS, Pune.

22.17. Role of the Central Government

Protection of coasts against erosion is the responsibility of the States. The local authorities were adopting such measures as appeared to be suitable to local conditions, based on the experience of protective measures against sea erosion carried out elsewhere or as advised by Research Stations in the country. In 1962, the Central Board of Irrigation & Power included the problem of coastal erosion in its fundamental research programme and studies were initiated at the Kerala Engineering Research Institute in consultation with the Central Water and Power Research Station, Pune.

In 1963, the Government of India obtained the services of an expert Mr. G. M. Watts from the Coastal Engineering Research Centre of the US Army Corps of Engineers to study the coastal erosion problem resulting from the 1963 monsoon season in the State of Kerala. He made certain recommendations, important ones being data collection for long-term planning and a trial of beach nourishment in the eroding coast as a method of protection. He also suggested a design of a rubble sea wall for protecting the coasts of Kerala. This visit was followed by the visit of another expert Mr. John L. Reynolds to give advice on construction methods and procedures to be utilised by the Kerala State for coastal protective works and to initiate an experimental beach nourishment programme at Purakkadu. He carried out his work and also gave some suggestions on the work being done by the Kerala State in pursuance of the earlier recommendations.

In 1964, Mr. G. M. Watts was again invited to inspect the constructed protective works and recommend measures to deal with erosion problems along the coast of the State of Kerala. He was also requested to make field inspections of the shore erosion problems in the States of Madras, Andhra Pradesh, Maharashtra and Orissa. His report contains useful information as well as specific recommendations for adoption by the coastal States.

One of his earlier recommendations was to form a Commission/Board or similar group of qualified individuals under the Central Government to provide views and recommendations to State Governments so that overall planning and treatment of programmes to develop the most effective and economical solution to the coastal problems could be achieved. Accordingly, the Government of India constituted the Beach Erosion Board in 1966 under the chairmanship of the then Chairman, CWPC, to initiate, guide and implement the programme of anti-sea erosion works in Kerala. Later in 1971, the Board was reconstituted to include all the coastal States. The Chief Engineers in-charge of the coastal works of the States concerned and a specialist in the field are Members of the Board. The Directors, Central Water & Power Research Station, Pune, is the Member-Secretary of this Board. The functions of the Board are:

(1) To organise a coordinated programme of collection, compilation, evaluation and publication of data relating to various natural phenomena and coastal processes which effect the coast line, through the coastal Engineering Research Centre and other State organisations.

(2) To arrange general investigations, studies and research in the Coastal Engineering Research Centre and State Research Stations.

(3) To lay down general design principles and construction techniques for anti-sea-erosion measures for the guidance of the State authorities.

(4) To review from time to time the performance of works carried out by the States and evolve improved design techniques based on such experience.

(5) To render technical advice on specific problems at the request of the States.

(6) To draw up a programme of training for personnel engaged in coastal engineering.

(7) To suggest other steps necessary for tackling the problem of coastal ersosion in an economic and coordinated manner.

The Reconstituted Board has held 7 meetings so far. In view of the great value of Geomorphological maps in the study and formulation of effective and scientific solution to the coastal engineering problems, the Board has initiated action to get such maps prepared. In the first instance, three typical reaches in Kerala, West Bengal and Gulf of Cambay in Gujarat have been selected. The preparation of the maps has been entrusted to the Geological Survey of India. The Board has also evolved guidelines for investigations for the planning and design of coastal protection schemes.

In 1976, the Government of India obtained the services of Mr. V. L. Maksinchuk, a Russian expert under the UNDP Programme, on a three months assignment with the Coastal Engineering Research Centre at Pune. He undertook examination and analyses of methods employed by the CWPRS for investigation of coastal problems. He held detailed discussions with the CWPRS staff on various aspects of the subject. He conducted field inspection of typical coastal sites of erosion in Bombay, Marmagoa and Kerala. He also gave lectures and issued notes covering the coastal engineering practices followed in the USSR.

His report contains suggestions on the improvments that can be made in the coastal engineering studies that have been undertaken in the Coastal Engineering Research Centre at Pune and also the improvements that are required in respect of the equipment for the Centre. He also suggested some change in the staffing pattern in the research centre and the need for obtaining some USSR experts and visits of the CWPRS staff to the institutions of Russia.

He observed that the reasons for failure of structures are due to inappropriate and inadequate provision of proper filters below the sea walls and absence of a proper size of stones between the filter and the armour layer. As regards off-shore breakwater studies, he suggested a three dimensional model approach for the best location and optimum submergence. He also suggested that statistical approach be attempted to predict the seasonal shore fluctuations and migration of mud banks. He also recommended study of bottom sediment characteristics offshore from ports and geomorphological aspects in greater detail.

THE CWPRS has been rendering advice in connection with investigations for the development of several major and minor ports with help of model studies. They have also been giving advice on specific protection works for areas subject to erosion. In particular, they have carried out investigations on the development of the ports of Bombay, Madras, Calcutta, Kandla, Mangalore, Cochin and Haldia. They have also carried out radioactive tracer studies in the field to determine the direction of the travel of bed sediment at Bombay, Cochin, Karwar, Goa, Sethusamudram, Bhavnagar, Mangalore and in the Hooghly. Floursecent tracer studies have also been conducted to determine the possibility of the silting of the proposed Mangalore Harbour as a result of which the location of the port has been changed. The work of proper planning and adequate designs of coastal protection works depends upon the field data collected at specific sites and laboratory research. The work proposed to be done at the research centre and the investigations carried out in the field will provide the necessary expertise to carry out the anti-sea erosion works.

22.18. Suggestions

In view of the foregoing, we suggest that:

(i) The Beach Erosion Board should meet more often and in any case not less than once in 6 months. Sub-committees in respect of different States may meet as required and their Reports considered by the Board during its meeting.

(ii) Erosion problems should not be considered in isolation nor on an ad hoc basis except in cases where protection cannot be postponed to safeguard permanent installations. Permanent solutions should be found by examining segments of coast between river mouths, head lands, or embankments and an overall plan prepared for treating the entire coast in a State.

(iii) Since artificial beach nourishment confines the problem to the area affected, every effort should be made to adopt this method wherever economically and practically feasible. If sea walls or revetments become inescapable, especially, for treating emergency situations, the design slopes should be so fixed as to be most economical in respect of the size of stones to be used and the design wave to be adopted. This aspect needs further research for meeting the conditions existing at different points along our coasts.

(iv) Data collection should continue on the basis of the recommendations made by experts. The Coastal Research Engineering Centre, CWPRS, Pune, should periodically evaluate the usefulness and reliability of the data collected and give guidance where required.

(v) Construction of shore protection works and their maintenance are costly. Therefore, it is essential that works interfering with the coastal processes are avoided as far as possible and the shore movements watched over a period of years before taking up protection works. To facilitate this, measures for land use and zoning for the coastal belt are considered essential. It would be short sighted to build permanent buildings or other costly installations very close to the shoreline and later spend exorbitant amounts in the course of years to protect them against the sea. The measures for land use and zoning recommended for cyclone areas can be extended to the vulnerable coastal reaches.

(vi) Construction of ports and harbours, big or small, generally create problems in the adjacent areas as the existing equilibrium is disturbed. It is necessary that enforceable remedial measures are undertaken for adequately safeguarding the interests of the people in the areas affected solely due to such construction. This would have a salutary effect in that the authorities will study the likely adverse effects of adjacent areas more thoroughly than at present.

(vii) We suggest that Government may review the sea erosion problem of various coastal States from the angle of rendering financial assistance to be given to them.

ANNEXURE 22.1

Summary of Recommendations made by I.M.D. in their cyclone project

Observational set up

Recommendation 1

Most of the part-time observatories along the east and west coasts of India should be converted into full time observatories. These should be provided with distinct reading equipment for measuring wind, pressure and tidal heights at a few selected places. The estimated cost for setting up these would be about Rs. 31 lakhs as capital and Rs. 8 lakhs recurring.

Recommendation 2

Upper air net-work along the northern portion of the west coast needs to be strengthened. It is proposed to convert all the 7 Pilot Balloon Observatories along the coast into Radio-Wind (Rawin) stations and also provide Radio-sende observations at Ratnagiri, Veraval and Bhuj. During the storm period the upper air observations should be more frequent. So all the coastal Rawin stations should take ascents at all the four standard hours of observations. The coast involved including the man-power requirement is estimated to be Rs. 120 lakhs as capital and Rs. 83 lakhs as recurring.

Recommendation 3

As a part of the INSAT programme, atleast 10 of the selected ships plying in the shipping lanes in the Arabian Sea and the Bay of Bengal should be provided with data collection platforms. The data from these ships will be available through INSAT at the collection centres from where they will be quickly relayed to the cyclone warning centres.

Recommendation 4

Survey of India has experience of maintenance of tide gauges and the additional net-work of 15 stations should also therefore be established by them. The arrangements for communication between the tide gauge locations and the CWC should, however, be made at all the 33 locations as none of the existing stations have any communication link. It would anvolve capital expenditure of about Rs. 32 lakhs.

Radar net-work

Recommendation 5

A Radar Station should be established over Gujarat coast. The radar at Visakhapatnam requires replacement. For this purpose Rs. 255 lakhs would be required towards capital and Rs. 220 lakhs as recurring expenditure.

Recommendation 6

At most of the places cyclone warning radars are located away from the cyclone warning centres due to technical considerations but its essential for a forecaster to see the radar picture continuously for making decisions on the movement and change in intensity of storm.

Some important features of Radar information are locally communicated on the telephone and the forecaster is not able to make a complete picture without seeing it. For a complete appraisal of the cyclone, it is necessary that each cyclone warning centre gets the radar pictures not only from its associated radar station but also from the adjacent radar stations.

For this purpose each cyclone warning radar would have to be provided with equipment which can transmit the picture to the concerned cyclone warning centre.

In the existing communication arrangements in the country, long distance video transmission is not possible. It would, therefore, be difficult to get these pictures directly. So, the next best arrangement would be to take a polaroid picture and transmit the same on telephone channels. The capital cost of transmiting and receiving equipment at cyclone warning radar stations and the cyclone warning centres would be around Rs. 195 lakhs as capital and Rs. 120 lakhs as recurring.

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Recommendation 7

Plans have been drawn up to provide the cyclone warning radars at Madras and Calcutta with additional equipment for digitising data. This facility may be provided at all the remaining cyclone warning radars. These cyclone warning radars should also have the videotaping and play back facilities. It would cost around Rs. 154 lakhs.

Air-craft reconnaissance

Recommendation 8

3 Aircrafts for cyclones reconnaissance with appropriate instrumentation may be acquired. The capital cost of the aircraft with instruments and

training works out to Rs. 45 crores (Capital) and the recurring cost of Rs. 6 crores.

Cyclone Forecasting Organisation

Recommendaion 9

24 hours watch should be introduced in Cyclone Warning Centres and Weather Central, Pune, and leave reserves in each cadre may be provided. Improvements in working conditions of staff be effected so as to minimise fatigue during long hours of work. This would involve an expenditure of around Rs. 20 lakhs as capital and Rs. 3 lakhs as revenue per year.

Telecommunications

Recommendation 10

(i) Provision should be made for voice transmission of data directly from the selected coastal observatories, both surface and upper air, to the cyclone warning centres concerned. After the Indian National Satellite Programme is implemented, some of these coastal observatories may be converted to Automatic Data Collection Platforms and their data collected through the satellite at the National Collection Centre.

(ii) A teleprinter line connecting the cyclone warning centre and the local telegraph office should be provided where it does not exist. All the cyclone warning centres and Weather Central, Pune, should be connected directly with Delhi by teleprinter.

(iii) Special frequencies should be allotted to IMD for collection of aircraft reconnaissance observations.

(iv) The handling of data at storm warning centres may be automatised through the use of a mini-computer. This would involve expenditure of about Rs. 245 lakhs towards capital and Rs. 125 lakhs as recurring.

Recommendation 11

(i) During the periods of cyclonic storm, P&T Department should position maintenance staff in the Meteorological Office for prompt rectification of faults or restoration of channels.

(ii) A mobile police W/T stations should be established temporarily for the duration of threat by the cyclonic storm in the premises of Meteorological Office for quicker communication with state officials.

Disaster Mitigation Measures

Recommendation 12

(i) A publicity cell may be organised in each Cyclone Warning Centre which will work in collaboration with news media and state publicity department to educate the public of coastal districts for pre and post disaster measures.

(ii) Appropriate disaster legislation at the Centre and state level is necessary.

(iii) After every disaster a complete summary should be made with a view to identify the lacunae in the organisation or service.

Training

Recommendation 13

An adequate number of specialists should be trained abroad in the forecasting/warning work, techniques of interpretation of data received from Aircraft reconnaissance, and Radar Synoptic meteorology, who in turn should help in building up a band of competent meteorologists in the field. It is estimated to cost around Rs. 7 lakhs as recurring expenditure.

Research

Recommendation 14

The Cyclone Warning Research Centre at Madras should be expanded into a National Cyclone Research Centre which will be responsible for development and evaluation of forecasting techniques. The expenditure likely to be occurred would be around Rs. 4 lakhs capital and 6 lakhs as recurring.

The total cost of implementation of above recommendations works out to be Rs. 10.56 crores towards the capital and Rs. 5.62 crores as recurring expenditure.

XXIII SUMMARY OF RECOMMENDATIONS

Floods—Incidence and Extent

1. The aggregate of different areas flooded at any one time during the period of record within the geographical limits of a State should be considered as the area "liable" to floods.

(3.6.2)

2. Detailed figures of flood damages, should, as far as feasible, be collected under the various sub-heads listed.

(3.6.4)

3. The degree of protection may be adopted according to the criteria decided for protection of various types of areas. The totals of such areas should be considered the "protectable" area.

   The extent of "protectable" area will undergo change from time to time, and, should be periodically reviewed.

(3.6.6)

Past Approach and Achievements

4. For the purpose of evaluation of the performance of the existing and future flood control works, data have to be collected in an effective manner so as to provide quantitative and dependable information on their long-term performance and their impact on various socio-economic factors.

(6.4.2—6.4.3)

Zamindari Embankments

5. The States should make a review of the utility of zamindari/test relief embankments depending on the importance of the areas protected.

(7.6.6)

6. Embankments which are considered useful should be incorporated in the overall flood control plan of the State.

(7.3.6 and 7.6.6)

7. Embankments which are not considered useful should not be retained but may be demolished or allowed to languish/disintegrate/disappear in course of time.

(7.5.5)

8. Embankments which are retained should be properly maintained.

   In cases where realigning is necessary, the possibility of utilising the old embankment as the first line of defence or as a local ring bund may also be examined.

(7.6.2 and 7.6.5)

9. No new test relief embankments should be constructed as far as possible except where they are part of the flood plan. Relief may be provided by raising and strengthening existing ambankments where necessary.

(7.6.6)

Effect of Developmental Works & Encroachments

10. There is need for closer coordination amongst concerned agencies like the Railways, National Highways, State Irrigation/Flood Control Departments so as to ensure that structures like bridges, roads, railways etc., do not aggravate flood problems.

(8.2.4)

11. Prior consultation by National Highway authorities, State P.W.Ds. and Railways with the State Irrigation/Flood Control Departments should be made obligatory. To facilitate an expeditious check, the Government of India should evolve a guideline|checklist for the purpose of vetting of waterways by the State Irrigation/Flood Control Departments.

(8.4.1)

12. It should be mandatory that assessment of adequacy of existing waterways should be made by the State Committee of Engineers or some other Technical Board and the waterways for bridges to be constructed in the future should be vetted by the State Irrigation/Flood Control Department.

    These Committees should be set up in States where they do not exist at present.

(8.4.3)

13. The Standing Committee for settling disputes on waterways and sharing of costs, headed by the Chairman, Central Water

Commission, should be vested with statutory powers for implementation of its decisions.

(8.4.4)

14. The State should undertake legislation to prevent unauthorised river bed cultivation and encroachments into drains etc., and where such laws already exist, the enforcement agencies should be strengthened.

(8.5.2)

Cultivation of crops like water-melons, vegetables, etc, in river beds and berms, may however, be allowed with caution.

(8.5.3)

The practice of cultivation in the abandoned beds of Dhars which discharge into main rivers should be stopped.

(8.5.4)

15. Where suitable legislation with a penal clause for unauthorised crossings over drains has not been enacted, the same should be done and enforced.

(8.5.5)

Methodology of Flood Damage Assessment

16. The final estimate of crop damage in areas where they are completely destroyed but resown/replanted should be made in terms of loss of inputs.

(9.5.2)

17. Information on (i) stage of the crop at the time of flood and (ii) crops completely destroyed and (iii) crops damaged but replanted/resown should be collected.

(9.5.2)

18. Crop losses in terms of money should be estimated by using farm harvest prices.

(9.5.5)

19. Crop yield rates should be derived from crop cutting experiments.

(9.5.5)

20. The collection of crop damage statistics should be integrated with that of agricultural statistics.

(9.5.11)

21. Wherever possible, contour maps along with gauge data should be used by the Flood Control Department to derive estimate of area flooded.

(9.6.1)

22. Remote sensing techniques operated through artificial satellite(s) may be used in selected areas to provide a sample check on the extent of area and cropped area affected by floods.

(9.6.2)

23. State Government should take measures for collection of data on damages to household goods. As a first step, they should aid and sponsor research and set up economic cells for conducting suitably designed economic surveys in this respect.

(9.7.1)

24. The monetary value of the cattle lost should be estimated. With regard to loss of human life, only that due to floods should be taken into account.

(9.7.1.)

25. In the case of public utilities, double counting of unrepaired damages of earlier years should be avoided.

(9.8.2.)

26. The estimates of damages to properties of the Central Government should also be included in the consolidated figures of damages at the State, national and other levels.

(9.8.4)

27. Departments dealing with flood control at the Centre and in the States should arrange for exploratory studies and sample surveys for throwing more light on the significance of indirect damages due to floods and for indicating norms for including them in the future.

(9.9.2)

28. Flood damage may be reported separately for the following three categories of areas:—

    (i) Unprotected areas;

    (ii) Protected areas; and

    (iii) Areas situated between the embankments and the river.

(9.10.1)

29. The extent of area affected by drainage congestion should be compiled separately for protected areas and unprotected areas.

(9.10.2)

30. Damage data should be compiled basin and sub-basinwise also.

(9.10.3)

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31. The district statistical office should supervise the work of damage data collection at the village and block levels and prepare estimates

(9.11.2 to 9.11.4)

32. At the State level the work of compilation and processing should be undertaken by the Directorate of Economics and Statistics.

(9.11.5)

33. At the national level, damage data should be compiled by the Central Water Commission with an Economics unit added to it. It should publish data at the national level.

(9.11.6)

34. Time schedules for submission of reports at various levels should be specified and adhered to.

(9.12.1)

35. At the State and national levels, there should be a periodical review of the methodology of data collection, compilation and publication.

(9.12.2)

36. The Central Water Commission should aid and encourage research in the methodology of flood damage assessment.

(9.12.3)

37. Finalisation of annual plans of States for flood control should be made contingent on their submitting final figures of flood damages.

(9.12.5)

Land Use and regulation

38. For estimating flood discharge from the watersheds a more refined and scientific approach should be increasingly adopted instead of empirical formulae.

(11.1.3)

39. Large scale reclamation of alkali soils in the Indo-Gangetic plains should be taken up to reduce drainage congestion in alkali areas.

(11.2.2)

40. Hydrological studies in experimental water-sheds should be intensified by the agricultural and forestry research organisations and similar studies in representative watersheds undertaken by the engineering research organisations.

(11.2.5)

41. Integrated action plan on soil conservation and watershed management should be prepared, implemented and maintained in the flood prone basins/sub-basins. The implementation agencies should be adequately strengthened with trained personnel. People's participation should be mobilised.

(11.3.5)

42. More and more forest areas should be declared as reserve forests.

(11.4.4)

43. The present programme for the control of shifting cultivation should be intensified and the concept of growth or urban centres in the fertile valleys developed on a pilot scale.

(11.5.3)

44. Urgent action should be taken to rationalise forest grazing.

(11.5.4)

45. Special attention should be paid to the problem of forest fires in the inaccessible areas of the Himalayan coniferous belt and the deciduous forest region of Central India.

(11.5.6)

46. Stabilising mine spoils should be made obligatory on the lessees.

(11.5.7)

47. In the Himalayan region, steps should be taken to stabilise roadside land slides and arrangements should be made to monitor the effects of land slides.

(11.5.9)

48. The highly eroded hill slopes, especially in the Himalayan region should generally be closed to grazing and suitable measures taken to develop them as grasslands.

(11.6.2)

49. Flood plain management measures should be undertaken wherever necessary legislation exists and suitable legislation enacted in other States.

(11.6.5)

50. A Central Land Use Commission should be set up and entrusted with the responsibility of bringing about uniformity in the existing land use regulations for enforcement in inter-State basins.

(11.6.6)

सत्यमेव जयते

51. Restructuring of cropping programme during the flood free months should be undertaken and suitable programme for irrigation should be launched.
(11.8.1)

52. State Government should construct community grain stores and undertake research to evolve improved design specifications.
(11.8.5)

53. Special flood-prone area programme similar to the Drought Prone Area Programme or Tribal Area Development Programme should be launched for rapid development of 'diara' land, along with appropriate research and development support.
(11.9.1)

54. Terracing for cultivation on steep slopes should be enforced as a general rule.
(11.10.3)

55. The State Governments of Assam, West Bengal, Bihar and Uttar pradesh may consider the extensive areas under 'tals', 'chaurs', 'beels' etc., as exclusively fishery resources under their land and water utilisation policy.
(11.16.1)

Costs and benefits

56. Cost-benefit analysis should be conducted for a complete range of viable alternatives.
(12.4)

सत्यमेव जयते

57. Measures should be taken for progressive adoption of social benefit-cost analysis. To begin with, high priority may be given to sponsor and encourge research in this field and economic cells created at the Centre and State levels.
(12.4)

58. Indirect benefits of a project to the extent they can be quantified should also be included.
(12.5)

59. Up-to-date norms for costs usually estimated as percentages of capital works should be determined.
(12.6.1)

60. Costs likely to be incurred in future on embankment protection works like spurs and revetments should be taken into account while working out the benefit-cost ratio.
(12.6.2)

61. A construction schedule with year-wise costs should be included in the project.
(12.6.4)

62. Estimates of cost and benefit figures of future years should be made on the basis of current prices.
(12.6.7)

63. The method of separable cost remaining benefits may also be taken into account for allocating cost of multipurpose projects having flood control as one of the components.
(12.6.8)

64. Area to be benefited from a flood control project should be estimated with the help of contour maps or with reference to the area flooded in some specific flood years in the past.
(12.7.2)

65. Flood damage data should be used for an assessment of benefits in monetary terms in States not following this practice.
(12.7.2)

66. Average annual damage should be derived from 15 to 20 years data after these are suitably adjusted for past changes in prices and productivity.
(12.7.3)

67. The cost of relief, rehabilitation, loans and remission of land revenue should not be taken into account in addition to direct losses for working out benefit-cost ratio.
(12.7.4)

68. The benefits on account of increased area being made available for cultivation and other purposes should also be taken into account.
(12.7.5)

69. Wherever applicable, the benefits of silt and inundation should be determined as the difference between yields of representative samples of flood affected farms and similar farms situated nearby in flood free area.
(12.7.6)

70. Damages that may continue to occur even after the construction of flood control works should also be dealt with in project formulation, and especially examined during scrutiny and sanction.
(12.7.7)

71. Care should be taken to obviate multiple counting of benefits in the cases of projects which are inter-related or undertaken at the same time.

While preparing a master plan/comprehensive plan, some idea of overall benefits and costs in a broad sense may be given.

(12.8)

72. Sensitivity analysis should be conducted for projects costing more than Rs. 50 crores.

(12.9)

73. Benefits and costs should be discounted at the prescribed interest rate.

(12.10.2)

74. The Planning Commission and State Planning Department should get some of the projects examined by independent outside agencies and draw the attention of the executive agencies towards discrepancies, if any.

(12.11)

Criteria

75. Selection of projects should be made with respect to criteria which should be objective, well-defined and expressed preferably in quantitative terms.

(13.1)

76. The criterion of benefit cost ratio be maintained. Projects showing benefit cost ratio exceeding unity should be deemed as qualifying for selection.

(13.3.4)

In case of additions to existing works, the benefit cost ratio criterion should be interpreted as the incremental benefit cost ratio.

(13.3.5)

77. The benefit cost criterion may be dispensed with only in special cases where benefits cannot be quantified in monetary terms. Instead, the criterion of cost effectiveness may be followed; and among the various feasible methods, the alternative of relocating settlements or installations should also be considered.

(13.4)

78. In the case of embankments, the design of a project should be determined for the time being on flood frequencies suggested. Meanwhile necessary steps be taken for the eventual application of benefit cost criterion for fixing the design flood.

(13.5.3)

79. Flood storage in reservoirs should be fixed taking into account different flood frequencies, safe channel capacity and the B.C. ratio.

(13.5.4)

80. The *inter se* priorities among flood control projects generally from amongst those included in the master plan should be fixed in the light of the following factors:—

(i) Benefit-cost ratio;

(ii) employment potential;

(iii) effects on environment and ecology; and

(iv) density of population in the flood affected areas as well as *per capita* expenditure on flood control in the project area.

(13.6.4)

Future approach

81. The comprehensive approach to the problem of floods must form part of the overall comprehensive approach for the best possible utilisation of our land and water resources for optimum production on a sustained long-term basis.

The approach to the flood problem should remain dynamic and flexible, so as to accommodate future improvements in policy, if called for, taking into account the state of our economy, our social conditions, and the availability of resources.

(14.2 and 14.25)

82. Various alternative measures, physical or otherwise should be considered for flood management and the optimum combination of the measures available in a given situation, selected.

(14.4)

83. There is a need for storage in various forms, which would even out the flow, and also conserve water for use during the dry period.

(14.5)

84. Afforestation and soil conservation measures are recommended as a useful complement to other measures, and should be taken up specially in the watersheds of rivers with heavy silt charge.

(14.6)

85. Reservoirs, to the extent technically and economically, feasible, must be considered as an important component in any package of measures for flood management.

(14.7)

86. Where conditions permit, storage of natural detention basins should be brought into use for flood moderation during abnormal floods.

(14.8)

87. Research and development regarding ground water recharge should be carried out.

(14.9)

88. While considering the use of embankments the associated problems and side effects should be kept in view, and minimised to the extent possible.

(14.11)

89. Because of high initial and maintenance costs, channel improvement measures should be considered with due caution.

(14.12)

90. Anti-erosion works should normally be taken up only for protection of towns, industrial areas, groups of thickly populated village abadis, railway lines and roads, where relocation is not possible on techno-economic grounds. These works should not be taken up for agricultural areas, where the assets protected may not justify the cost.

(14.15)

91. Measures for drainage improvement should be planned and executed in a coordinated manner. Measures for irrigation and drainage should be integrated.

(14.16)

92. Measures to modify the susceptibility of life and property to flood damage should be adopted to much more increasing degree than heretofore.

(14.17 to 14.20)

सत्यमेव जयते

93. Measures for modification of the loss burden like disaster relief, remission of taxes and taccavi loans etc. should be continued.

(14.22)

There is need to conduct research, and if possible, take up pilot projects for flood insurance.

(14.23)

Planning and implementation

94. Floods should find a place in the comprehensive planning for water resources development. The first choice should therefore, be to undertake comprehensive water resources development in a river.

(15.2.1)

95. It would not be advisable to hold over flood plans pending the preparation of comprehensive water plans.

(15.2.1)

96. Flood space should be provided in reservoirs after examining the need and feasibility.

(15.2.3)

97. Unless flood control/moderation by a reservoir is visualised within the next 10 years, its contribution should not figure in the solution of a flood problem.

(15.2.3)

98. Flood Master Plans should not in any way vitiate or conflict with future comprehensive plans for water resources development.

(15.2.4)

99. A river basin is the most suitable and proper unit for preparation of water and flood plans.

(15.2.5)

100. It is advisable to visualise flood works which may be needed for different reaches of the river and take account of their inter-action.

(15.2.5)

101. Soil conservation and afforestation measures be stepped up.

(15.3.2)

102. Local factors may be taken into account and standards for planning and design of surface drains fixed by areas/regions in each State.

(15.4.1)

103. Drainage schemes undertaken in irrigated areas and for the purpose of land reclamation should not form a part of "flood" sector.

These schemes should however, be discussed in the Technical Advisory Committees of the State Flood Control Boards.

(15.4.3)

104. Due attention should be paid to the environmental changes likely to be brought about by a flood and/or a water resources development project.

(15.5.4)

105. The recommendation, that the work of preparation of contour maps in flood prone areas be taken up by the Centre, is supported.

(15.6.2)

106. Where the work-load justifies, the investigations and planning of flood schemes may be independent, but designs of both flood and irrigation schemes should be entrusted to a unified Design Organisation in a unified Department.

(15.8.1)

107. The staff employed for investigation, planning and design should be adequate in calibre and strength.

(15.8.2)

108. Investigations of extensive and complicated projects should be carried out under a special "Investigations" estimate.

(15.8.3)

109. Benefit-cost ratio should be worked out for all schemes. (15.8.4)

110. Consultations and coordination be effected with departments likely to be concerned with/affected by projects.

(15.9)

111. Planning of inter-State rivers should be done basinwise by Basin Authorities.

(15.10)

112. Negotiations should be expedited between Nepal and India with regard to the construction of storages and development of water resources.

(15.11)

113. Unless adequate maintenance is assured, it is unwise to undertake new construction.

(15.12.3)

114. It is important not only to bring more area under watershed management and soil conservation treatment, but also to take measures to stop damage to further areas as also to maintain areas that are treated.

(15.12.5)

115. Barring exceptional cases, priorities fixed in the Master Plans should be strictly followed.

(15.13.2)

116. Completion of continuing schemes should receive priority in allocation of funds, to the extent necessary, by and large, not less than 60 per cent of Plan and Annual allocations.

(15.13.3)

117. Attempts should be made to obtain public participation.

(15.14)

Financing

118. Some resources should be mobilised from beneficiaries of flood control schemes. (16.2.2)

119. The amount collected from the beneficiaries should be set apart for the maintenance of flood control schemes.

(16.2.3)

120. The flood cess should be collected along with existing taxes.

(16.2.3)

121. To start with, a cess of 1 per cent and 3 per cent of the capital cost of flood protection and drainage works respectively should be recovered. In the case of river bank erosion projects, allocable costs should be recovered from the beneficiaries.

(16.2.3—16.2.4)

122. Flood control sector be given preferential treatment while making allocations from funds meant for special problems.

(16.3.4)

123. Funds for specific schemes in the flood control sector should be earmarked. However, some flexibility should be provided to take care of special situations.

(16.4.2)

124. The Central Government should do the earmarking in the case of inter-State projects and large projects costing more than Rs. 2 crore each and those in advanced stages of construction.

(16.4.2)

125. The outlay on flood control in States having a large backlog of continuing schemes should be increased and a greater proportion of the outlay be set apart for such schemes.

(16.4.2)

126. Schemes at locations, where emergent situations have been met during floods, should be undertaken only according to priorities fixed in the overall context.

(16.5)

Maintenance

127. For the maintenance of structural measures in soil conservation and watershed management during the first 3-4 years a provision of 4-5 per cent of the cost of works should be provided in the original estimates. Thereafter, maintenance should be the responsibility of the beneficiaries.

(17.3.3)

128. The methods and procedures detailed in the Embankment Manual and the Manual of Flood Operations compiled by the erstwhile CW&PC are adequate and should be normally followed.

(17.3.14)

129. The actual requirements of work, men and materials required for maintenance should be fixed for each location/State.

(17.3.18)

130. Instructions for watershed management and land treatment measures should be circulated.

(17.3.18)

131. Charging "maintenance" to "capital" under various forms should be discouraged.

(17.6.4)

132. Adequate funds for maintenance should be assured. Amounts for maintenance suggested for various types of works may be taken as a guide. These should be reviewed by the State officers on the basis of actual needs, and, norms fixed. These norms should be reviewed periodically.

(17.7.1)

133. In order to deal with emergent situations, emergency financial powers and discretionary grants should be given to specified officers.

(17.7.2)

134. The Planning Commission should, before granting Annual Plan funds for new and continuing flood schemes, ensure that the State is making adequate provision for maintenance of existing works. A record of failure of control/protection works should be maintained and details supplied to CWC/GFCC, as also a resume to the Planning Commission.

(17.7.3)

135. Suitable checks of levels and cross sections of works like embankments, drains, drainage channels, etc., should be exercised by higher officers.

(17.8.1)

136. In areas of high rainfall, some kind of surfacing should be provided on earthen embankments.

(17.8.2)

137. Arrangements should be made for connecting by telecommunication links, all points of important flood and drainage works to the headquarters of superior engineering officers and the control room of State headquarters.

(17.8.3)

138. All drains, whether dug or natural, should be properly maintained up to their outfalls.

(17.8.4)

139. Wherever sub-standard installations like ex-zamindari embankments, and test relief works are handed over to the Flood Control Department, funds should be provided to upgrade them to proper standards.

(17.8.5)

140. Additional funds should be allocated wherever embankments are used as public highways.

(17.8.6)

141. In emergent situations, the engineer-in-charge should take control of all operations. All Departments should render necessary assistance to him. Voluntary organisations of the locality should also be involved in works during such emergencies.

(17.8.7)

142. Proper training in maintenance of flood works should be imparted to the concerned persons like unskilled labour, Government officers, Home Guards, local people, etc.

(17.9)

Organisation

143. River Basin Authorities should be set up for preparing plans by basins/sub-basins of inter-State rivers.

(18.7.1)

144. For development of basins/sub-basins of inter-State rivers, the personnel for River Basin Authorities should be drawn from multi-disciplines.

(18.7.3)

145. A Central Authority may be constituted in due course of time with the Prime Minister as the Chairman and should be assisted by a strong technical body.

(18.7.5)

146. Non-recurring and recurring costs of Basin Authorities should be fully met by the Centre.

(18.7.6)

147. Pending constitution of the Central Authority, the State Irrigation Ministers' Conference may carry out its duties.

(18.7.7)

148. The organisation giving technical assistance to the State Irrigation Ministers' Conference may be strengthened in order to discharge additional functions.

(18.7.7)

149. River Basin Authorities should be constituted as statutory authorities.

(18.7.8)

150. It would be preferable to have unified Irrigation and Flood Control Departments in the States.

(18.8.2)

151. Cells should be constituted for specialised items.

(18.8.3)

Legislation on flood control

152. The Central Government should assume the powers conferred on it by the Constitution under entry 56 of the Union List and enact suitable legislations for the regulation and development of inter-State rivers.

(19.4.9)

153. The States should enact legislation so as to amend Section 17 (ii) of Land Acquisition Act with a view to make the existing provisions for emergent situations, at present applicable to Railways, also applicable for flood control works.

154. The Central Government should prepare a Model Bill dealing with all aspects of flood control to serve as a guide for the State Governments.

(19.9 and 19.10)

Collection and Publication of data

155. The present coverage of rainfall stations in hilly areas should be strengthened.

(20.3.2)

156. The minimum density of self-recording raingauge network should be increased to 20 per cent.

(20.3.2)

157. A special Task Force should be appointed for finalising the hydrological network and a time schedule should be laid down for implementation.

(20.3.4)

158. The Central Government should exercise technical direction to ensure uniformity and continuity in the collection of hydrological and other data.

(20.3.4)

159. The hydrological data collection of all inter-State and other important rivers should continue to be undertaken by the CWC, till the formation of River Basin Authorities, when the matter could be reviewed.

(20.3.4)

160. Contour surveys and preparation of maps of flood prone basins should be taken up immediately.

(20.4.2)

161. Using modern technology, land resources surveys for the catchments of the flood-prone rivers should be taken up on a priority basis.

(20.5.2)

162. Use of advanced methods like telemetering devices, radar, etc., should be intensified.

(20.6.5)

163. The CWC should review and standardise the existing forms and procedures in respect of hydrological data collection in the context of modern developments in this field. The finalised forms should be brought into use throughout the country within a time bound schedule.

(20.7.3)

164. The CWC through their regional centres should be entrusted with the responsibility of co-ordinating the data collection programme in the regions, as well as evaluation of the results of the completed projects in the light of benefits assumed.

(20.7.4)

165. A Central Data Bank should be established in the CWC where all data collected should be stored. It should have computer facilities for storing as well as retrieval. Suitable software for specific needs should be developed for processing of data for supply to different users.

(20.7.5)

166. The States should take immediate steps to publish the available data. Similarly the Central Water Commission should make up the time lag in the publication of Water Year Books.

(20.8.2)

Research, education and training

167. More emphasis should be laid on research, education and training as relevant to water resources development, river science and control of floods.

(21.1.1—21.2.3)

168. Central and State research organisations concerned with water resources development and water problems should increasingly participate in international programmes.

(21.3.1—21.3.2)

169. Early steps should be taken to establish the Documentation Centre on modern lines at the Central Water & Power Research Station, Pune.

(21.5.1)

170. Current research and development efforts should be geared to achieve automatic use of radar information for hydrological work.

(21.6.1)

171. Further studies should be carried out to improve the existing watershed models for using remotely sensed information in order to predict flood flow under inadequate or no data situations.

(21.6.2—21.6.5)

172. Pilot studies on the use of remote sensed data for a few sub-basins in a couple of inter-State flood-prone rivers should be undertaken.

(21.6.6)

173. Usefulness of scanner survey for flood plain mapping should be assessed.

(21.6.7)

174. Appropriate research studies on prototype performance of hydraulic structures of check dams, small detention reservoirs etc. should be undertaken in order to evolve technical manuals for adoption in different soil-climatic regions.

(21.6.8)

175. Scientific plans of research projects on hydrological studies should be drawn up carefully after identifying suitable watersheds to represent major soil-climatic zones. In the first phase, planned studies in a few experimental and representative watersheds of the major flood-prone rivers should be implemented.

(21.6.10)

176. The existing research organisations should intensify their research investigations to obtain scientific information on river morphology and river response to various hydraulic structures and encroachments.

(21.6.11)

177. Scientific research should be taken up to determine the value of hydraulic conductivity, rate of water table fluctuations and intake rates under different soil conditions, self cleaning velocities in drains and drainage indices for different regions of the country and to obtain information on the crop response to different depths, turbidity, and soluble salt content, both under stagnant and flowing water conditions.

(21.6.12)

178. Efforts should be intensified to evolve more and more mathematical models and use them to remove empiricism and introduce better rationality in decision making processes.

(21.6.13)

179. Scientific surveys and investigations to determine the contribution of snow and glacier melt to annual floods in the Himalayan rivers should be intensified.

(21.6.14)

180. Research should be intensified to determine the effects of industrial pollution on structural materials and to evolve methods to maintain water quality.

(21.6.15)

181. Studies on sedimentation of reservoirs should be intensified.

(21.6.16)

182. Suitable research should be taken up to determine the effects of aquatic weeds on the loss of water in storage and interference with the flow conditions.

(21.6.17)

183. Intensive studies should be undertaken not only to identify suitable recharge areas for flood water absorption and recharging the ground aquifers but also an efficient methodology to execute such recharging programmes in the field on an operational scale.

(21.6.18)

184. Intensification of research is recommended on newer items of construction material like reinforced earth, fibre, reinforced concrete, etc. for use in river training works etc.

(21.6.19)

185. Suitable pilot operational projects should be taken up to establish the economic feasibility of the proposed 'Range-Feedlot' system of cattle management.

(21.6.21)

186. Techno-economic research should be sponsored in order to develop new technology for flood control and methodology for quantifying indirect damages and indirect benefits.

(21.6.22)

सत्यमेव जयते

187. A review of the adequacy of the present research organisations concerned with water resources development and water problems should be carried out. Pending this review, intensification of the current research efforts should be effected.

(21.7.1-21.7.2)

188. Regional Research Institutes under the National Institute of Hydrology should be established.

(21.7.2)

189. 'Barh Vigyan Kendras' should be established where training of land users and young students should be taken up.

(21.10.1-21.10.2)

Cyclones and sea erosion

190. The recommendations contained in the project report prepared by the IMD for better forecasting and warning are endorsed.

(22-6-2)

191. Human activities should be restricted in areas which are exposed to cyclones.

(22.6.3)

192. Disaster prevention policies should be encouraged.

(22.6.3)

193. The general range of land use regulation recommended for flood-prone areas may be applied for cyclone hit areas.

(22.6.3)

194. Casuarina and other plantations, whereever feasible, should be established as windbreakers for a width of about 2 km along the sea coast.

(22.6.3)

195. Shelter buildings, especially designed for cyclone conditions should be constructed in the coastal areas.

(22.6.3)

196. Future coastal embankment projects in deltaic areas should be planned in conjunction with other development projects such as highways, harbour and reclamation projects.

(22.6.3)

197. A National Council for mitigating disaster should be formed.

(22.6.4)

198. Adequate network of operational communication facilities connecting the warning service to all concerned and to one another for consultation and co-ordination should be established.

(22.6.4)

199. Planning and organisation of disaster preparedness should be kept under constant review.

(22.6.5)

200. Rehabilitation should aim to improve, rather than merely restore accustomed living standards and social conditions.

Resettlement should ensure that temporary settlements would become permanent only if they are suitable.

(22.6.7)

201. Financing of engineering works like coastal embankments and permanent shelters as protection measures should follow the practice as for flood control schemes.

(22.6.8)

202. The Beach Erosion Board should meet more often and in any case not less than once in six months. Sub-committees in respect of different States may meet as required and their Reports considered by the Board during its meetings.

(22.18)

203. Erosion problems should not be considered in isolation nor on an *ad hoc* basis except in cases where protection cannot be postponed. Permanent solutions should be found by examining schemes of stretches of the coast between river mouths, high lands, or embankments, and, an overall plan prepared for the entire coast in a State.

(22.18)

204. Data collection should continue on the basis of recommendations made by experts.

The Coastal Research Engineering Centre, CWPRS, Pune should periodically evaluate the usefulness and reliability of the data collected and give appropriat guidance where required.

(22.18)

205. Works interfering with the coastal processes should be avoided as far as possible and the shore movements watched over a period of years before launching protection works.

(22.18)

सत्यमेव जयते

206. Remedial measures should be undertaken for adequately safeguarding the interests of the people in the areas affected by the construction of coastal works like ports and harbours.

(22.18)

207. Government should review the sea erosion problem of various coastal states from the angle of rendering financial assistance to them.

(22.18)

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NEW DELHI, 20*th March,* 1980.

An index of the technical material, which was available with the Ayog for its use and reference, is listed as Appendix IX Volume II of the Report. In addition, Members of the Ayog frequently borrowed literature from various libraries and sources of information like UNDP, USIS, CWC, ICAR, etc., etc., However, following is the major list of references which were made use of by the Ayog in its Report—

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ERRATA

Page No.	Column Left/Right (L) (R)	Paragraph/Table/ Annexure No.	Line	As printed	As desired
(1)	(2)	(3)	(4)	(5)	(6)
5	R	1.16	28	precuring	procuring
12		Annex. 1.5	2	Organisation	Organisations
13	R	2.3.2	8	callad	called
14	L	2.3.3	7	outrall	outfall
15	L	2.5.1	3	joing	joining
17	R	2.6(i)	19	flow	flows
18	L	(iii)	24	Etah	Etawah
19	R	(viii)	18	districts	district
20	L	(ix)	7	out	but
20	L	(x)	2	605	605 m
20	L	(xi)	8	Trivani	Triveni
20	R	(xvi)	7	Everst	Everest
21	R	(xx)	6	Barkura	Bankura
22	L	(ii)	10	of Kashmir	of Jammu & Kashmir
24	L	2.8.6	5	But about	About
24	R	2.8.8	28	Westen	Western
25	L	2.8.9	5	Marutia	Marutla
25	L	2.8.9	7	Penner	Pennar
25	L	2.8.10	13	Kabbni	Kabini
25	L	2.8.10	17	97	91
25	R	2.8.10	12	canal	canals
26	L	(v)	4	flows	follows
26	L	(v)	5	distributary	tributary
28	L	(xxiii)	4	Aari	Aar
29	R	(xxvi)	1	Valgai	Vaigai
32	L	2.9.1(i)	1	25,000 sq. km.	25,900 sq km.
32	L	2.9.2	23	plteau	plateau
33	R	(iii)	1	Raropur	Rampur
34	L	(vii)	1	cathment	catchment
34	R	(ix)	15	Andhwara	Adhwara
34	R	(x)	7	rives	river
36	L	(xix)	8	through	though
38	R	(iv)	5	Branmani	Brahmani
39	L	(vi)	18	the	Its
39	L	(vi)	26	wealthering	weathering
39	R	(vi)	10	ths	the
39	R	(vii)	21	palteau	plateau
44	R	3.5.2(i)	13	resuit	result
49	R	4.3.2	4	925	9.25
51	R	4.5.2	11	where	were
51	R	4.5.2	12	comperatively	comparatively
52	R	4.5.4	6	at	of
52	R	Table 4.3	5	constan	constant
54	R	4.6.13	1	accounted	accounted for
55	L	4.6.18	17	sizeable	sizable
58		Annex. 4. 1	7	Oissa	Orissa
68	L	Annex. 4. 7	1	constant prices	constant
83	L	5.1	21	volunerability	vulnerability
84	L	(i)	3	project	projects
84	R	(v)	16	evulsion	avulsion
84	R	(b) Heading	2	dranage	drainage
84	R	(c)	5	try	tie
85	L	(c)	2	and	an

(1)	(2)	(3)	(4)	(5)	(6)
86	R	(v)	1	continues	continuous
87	R	(b)	28	barriers	barrier
87	R	(b)	54	maintenanee	maintenance
90	L	5.4	49	dminish	diminish
90	R	5.5	36	effctes	effects
94	R	5.7.2	1	Radistribution	Redistribution
94	R	(c)	26	were	was
102	L	(iv)	3	raising	rising
103	L	(vii)	1	insurances	insurance
105	R	(ii) Table Col. 4	1	Plan site	Plan size
107	R	6.4.1	8	ond	and
108	L	Table Col. 2	3	19174	1174
110	L	6.4.2	23	evaluation	evaluations
110	R	6.4.2	13	people the	people of the
112	L	(ii)	2	cumees	cumecs
113	L	6.4.6.	16	GMCC	GFCC
113	K	6.4.7	7	programme	programmes
114	L	6.4.8 (iii)	21	Apprdiximate	Approximate-
117		*Annex*. 6.2			
		10. Madhya Pradesh (under 1966-69)	17	0.02	0.08
		15. Orissa (under 3rd Plan)	22	0.98	2.93
		(under 4th Plan)	22	5.00	5.30
		16. Punjab (under 3rd Plan)	23	27.31	27.81
		(under 4th Plan)	23	12.01	12,81
		17. Rajasthan- (under 2nd Plan)	24	9.08	0.08
		22. West Bengal (under 1st Plan)	29	3.64	1.64
		Total (1st Plan)	30	1.16	13.16
118		Annexur 6.3	1	Achieoement	Achievement
		Bihar (under upto 1972)	9	18.40	12.40
		Gujarat (under upto 1969)	10	0.47	0.41
120		Annex. 6.5.	2	Achienement	Achievement
121		Annex. 6.6.	3	Townns	Towns
126	R	7.3.6.	12	drawbacks	drawback
131	L	8.2.2.	11	earthquafl or	earthquake of
133	L	Uttar Pradesh	3	erossing	crossing
141	R	8.4.4	47	Transpprt	Transport
144	L	8.5.2	42	'Talas'	'Tals'
149	R	Annex. 8.4.	2	use nn in	use in
153	L	9.4 Heading	1	Methology	Methodology
153	L	.4.2	9	uch	such
153	R	4.3	34	methodolagy	methodology
154	L	9.5.1	22	statiscics	statistics
161	L	10.1	34	inte se	inter se
162	L	10.2.2 Heading	1	Recomendations	Recommendations
163	L	10.3.3	11	deptn	depth
163	R	10.3.4	11	it any	if any
164	R	Table III	10	Rajsthan	Rajasthan
166	R	Table of 'A	6	Goalparax	Goalpara
167	L	Table of 'B	6	hax	ha
167	L	Table of 'B	23	aras	areas

(1)	(2)	(3)	(4)	(5)	(6)
167	L	Bihar 'A' Heading	1	yood	flood
168	R	Delhi 'A'	6	availabe	available
169	L	Table Col. 2	Sl. No.10	trihutary	tributary
170	R	B.	6	ideniified	identified
172	R	A.	6	973	1973
173		Table	12	respet	respect
174	R	Table of A.	7	320.2.2	302.2
175	L	Category C	1	Lulnow	Lucknow
176	R	C.	Sl. No.2	Vjoy	Ajoy
177	R	11.1.1	4	plans	plains
179	L	Table 11.1	Col.3	created	treated
179	R	11.2.3	4	sq^1	sq km^1
184	R	11.5.7	4	aeras	areas
184	R	11.5.8	11	silde	slide
189	L	11.8.1	4th & 16	reverine	riverine
189	R	11.8.1	23	initensifyng	intensifying
192		Source	1	or	for
194	L	11.12.1	30 & 35	seeding	seedling
195	L	11.14.1	9	Benbal	Bengal
197	R	11.17.1	2	'diaras'	'diara'
199	R	Annex. 11.2	1	4, 1979	11, 1974
201	R	Annex. 11.3	4	own	sown
opposite 202		Figure 11.1	Bottom	11.27	11.1
210	L	12.7.5	8	foothils	foothills
210	R	12.7.6	32	an	and
211	L	12.7.8	22	concurrentiy	concurrently
212	L	12.10.3	10	an	and
212	R	12.10.3	10	mtehod	method
217		Annex. 12.3 Heading	Col. 4	or present worth	(or present worth)
227	L	14.2	18	everemphasised	overemphasised
229	R	14.11.2	Heading	Vulunerability	Vulnerability
230	R	14.16.1	7	inportant	important
232	R	(iv)	2	plans	plains
234	L	14.27.1	40 & 44	'haors'	'hoars'
234	R	14.27.1	1	riverr	river
234	R	14.27.1	30	suices	sluices
236	R	14.27.2	10	he	the
236	R	14.27.2	48	rives	river
237	L	(iii)	8	exeeption	exceptional
239	R	14.28	6 & 7	interchange as lines	7 & 6
241	L	14.28.1	7	disasterous	disastrous
242	R	14.28.2	43	plainning	planning
254	R	14.28.2.7	14	citical study	critical study
254	R	14.28.7	19	Warraka Barrage	Farraka Barrage
257	L	14.29.2	30	70.29.2	14.29.2
257	R	..	26	vulnorable	vulnerable
257	R	..	33	he existing	the existing
258	L	Measures taken so far	18	shemes	schemes
265	L	14.30.5	21	Delat	Delta
265	L	14.30.5	23	229.57	209.57
265	R	14.30.6	52	encorachments	encroachments
268	..	Annex. 14.1	12	side-effeects	side-effects
276	.L	15.12.5	1	aforestation	afforestation
281	R	16.4.1	25	chages	changes
281	R	16.4.1	35	of	or
284	R	(9)	2	ben	been
291	L	17.4.4	28	eventh	Seventh

(1)	(2)	(3)	(4)	(5)	(6)
292	R	17.6	31	Pakladiya	Pagladiya
295	L	..	20	17.0	17.9
295	R	17.9	7	emmankment	embankments
297	L	18.2.8	19	Damodar dar river	Damodar river
305	R	19.4.1	9	fiazette	gazette
308	R	19.5.5	12	recovered instalments	recovered in instalments
313	L	:9.7.1	15	majod	major
313	R	(v)		Heading Plan	Plain
322	L	20.4.2	54	1 mile (: 16000)	1 mile (1 : 16000)
322	R	20.4.2(i)	6	predequisite	prerequisite
322	R	20.4.2(iii)	3	flood prone .. future	flood prone rivers both fox future
323	R	20.5.4	2	now	know
323	R	20.6	12	rador	radar
325	L	(c)	6	physicol	physical
328		Annexure 20 (i) under Col. No. 4	Item	14	19
329		Annexure 20 (ii) Col. No.3	29 (Total)	721	781
337	L	21.6.12	5	agrcultural	agricultural
337	R	21.6.13	4	woter	water
337	R	21.6.15	13	works	—
338	L	21.6.19	12	reingorcer	reinforced
339	R	21.7.2	5	kowing	flowing
339	R	21.7.2	5	basinc	basins
339	R	21.8.2	5 & 6	professonal	professional
340	L	21.9.2	4	Rookee	Roorkee
340	R	21.10.2	9	pdogrammes	programmes
342	R	22.2	10	storm	storms
342	R	22.3	2	cyclones	cyclone
343	L	22.3	8	comulative	cumulative
343	L	22.4.1	Before this,	read para heading Affected	No. 22.4 State
343	R	22.4.2	8	district	districts
352	L	22.10.2	11	repodt	report
356	L	22·14·5 Table	16	cost odf	cost of
357	L	(7)	2	ersosion	erosion
357	R	22.17	52	THE	The
358	L	22.17	3	Floursecent	Flourescent
359	L	Annex. 22.1 Recommendation 4	8	anvolve	involve
359	R	Annex. 22.1 Recommendation 6	25	transmiting	transmitting
361	R	9	5	ambankment	embankment
369	L	151	2	specialsed	specialised
371	R	204	8	appropriat	appropriate

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